ANNALS
OF
The Entomological Society of America

Volume X JUNE, 1917 Number 2

A SYNOPSIS OF THE GENERA OF BEETLE MITES WITH SPECIAL REFERENCE TO THE NORTH AMERICAN FAUNA

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The beetle mites constitute, it is believed, a natural group of the order *Acarina* which, because of its close affinities with some of the other groups of mites, is rather hard to limit or define properly. As considered here, the group includes only those mites which possess, in addition to a hard, chitinous exoskeleton, a pair of modified setæ on the posterior dorsal aspect of the cephalothorax, known to specialists as the pseudostigmatic organs. Thus limited, the beetle mites have been recognized by some workers only as a family, by others as a superfamily, and by several of our foremost authorities as a sub-order. Michael in his treatise on the group[1] considered it as a family, the *Oribatidæ*, which he divided into seven subfamilies. Banks has considered the group as a superfamily, *Oribatoidea*, which formerly he divided into two families, *Hoplodermidæ* and *Oribatidæ*. Recently he has included the family *Labidostommatidæ*[2] also in the superfamily, but this family would not be included in the group as just defined by the writer. Oudemans regards[3] the group as one of the twelve of his subdivisions of the whole order, and gives to it the name of *Octostigmata*. The present writer in 1913, gave a classification of the Acarina[4] in which the tarso-

[1] Michael, A. D. Oribatidæ. Das Tierreich, Lieferung 3, 1898.
[2] Banks, N. The Acarina, or Mites. Report No. 108, U. S. Dept. Agric., 1915.
[3] Oudemans, A. C. A Short Survey of the More Important Families of Acari. Bul. Entom. Research, Vol. I, pp. 105-119, 1910.
[4] Ewing, H. E. New Acarina, Part I. Bull. Amer. Mus. Nat. Hist., Vol. XXXII, Art. V, pp. 93-121, 1913.

nemid mites were included with the beetle mites in a suborder called *Heterotracheata*. The beetle mites were divided into two sections under this suborder, *Ginglymosoma* and *Scleroderma*. The former section included the family *Hoplodermidæ* and the latter the families *Hypochthonidæ*, *Nothridæ*; and *Oribatidæ*. Berlese has in the last few years described some interesting new species, which show both the characters of the family *Hoplodermidæ* and also those of the families *Hypochthonidæ* and *Oribatidæ*. These should, I believe, be regarded as the direct descendents of the "connecting links" between these families, and their discovery must necessarily cause us to regard the *Hoplodermidæ* as being more closely bound to the other families than was formerly believed.

Considering the beetle mites as a phylogenetic unit, disregarding for the present their place in the order to which they belong, we find that they can be easily divided into four families already recognized by others. These four families I have divided into fourteen subfamilies, which are given with the families in the following key:

A KEY TO THE FAMILIES AND SUBFAMILIES OF THE BEETLE MITES.

A. Cephalothorax immovably united to abdomen; tracheæ usually present.
  B. Abdomen without dorsal grooves or sutures dividing it into parts; integument well chitinized.
    C. Abdomen provided with chitinous, wing-like expansions known as pteromorphæ, which usually are large and conspicuous, but which may be small and shelf-like.....**Oribatidæ**
      D. Cheliceræ swollen at their bases, styliform beyond, and ending in minute chelæ.....PELOPINÆ
      DD. Cheliceræ stout in the middle and with large chelæ....ORIBATINÆ
    CC. Abdomen without wing-like expansions known as pteromorphæ, even of the rudimentary, shelf-like type.....**Nothridæ**
      D. Cheliceræ rod-like, serrate toward their tips.....SERRARIINÆ
      DD. Cheliceræ not rod-like, chelate.
        E. Fourth pair of legs fitted for jumping.....ZETORCHESTINÆ
        EE. Fourth pair of legs not fitted for jumping.
          F. Lamellæ present, being either blade-like or in the form of straight chitinous ridges.
            G. Integument of dorsal surface of abdomen smooth, and without markings of any kind.....NOTASPIDINÆ
            GG. Integument with markings in the form of reticulations, tubercles, pits, sculpturings, or ridges.....TEGEOCRANINÆ
          FF. True lamellæ absent, but crooked or irregular ridges may be present.
            G. Some of the segments of the legs other than the femora swollen toward their distal ends and pedicellate proximally; legs slender.....DAMAEINÆ
            GG. None of the segments of the legs swollen and pedicellate except the femora.
              H. Ventral plate present, and usually containing the genital and anal apertures.....NOTHRINÆ
              HH. Ventral plate absent or rudimentary, and in no case inclosing genital and anal apertures.....LOHMANNINÆ

BB. Abdomen divided into areas dorsally by grooves or sutures making it appear segmented; integument usually poorly chitinized..**Hypochthonidæ**
C. Dorsal sutures of abdomen oblique; segments of legs inflated..TRIZETINÆ
CC. Dorsal sutures of abdomen transverse; segments of legs not inflated, HYPOCHTHONINÆ
AA. Cephalothorax hinged to abdomen; tracheæ absent.....**Hoplodermatidæ**
B. Abdomen divided into parts, as if segmented, by transverse grooves or sutures.....PROTOPLOPHORINÆ
BB. Abdomen not divided into parts, as if segmented, by transverse grooves or sutures.
C. Genital and anal openings situated in a large ventral plate which is anchylosed to dorsal plate.....MESOPLOPHORINÆ
CC. Genital and anal openings not situated in a large ventral plate, anchylosed to dorsal plate.....HOPLODERMATINÆ

These fourteen subfamilies contain many genera; especially is the subfamily *Oribatinæ* rich in genera. I have tried in the following pages to key out as many of the genera of the very large number proposed as appeared to be based upon good characters, and to be acceptable from the standpoint of nomenclature. However, a few genera appear to be good, that I have not been able to place in my keys, because of incomplete data on their generic characteristics. Many proposed genera will not be found in my keys. For various reasons some twenty-four of these have been excluded. Some were founded upon characters which I regard as purely specific; others are almost, if not exact, synonyms of older genera; others have names which are preoccupied; and yet others have been rejected for various reasons not here mentioned.

In the keys which follow, readers will find given with each genus the name of its author, the date of its establishment, and the name of its type species. Lack of space forbids a discussion of taxonomic points involved in the fixing of some of these types. In a few cases these will be given briefly in footnotes.

Family ORIBATIDÆ.

Key to the Genera of Subfamily Pelopinæ.

a. Abdomen with a shelf-like expansion extending forward from its anterior margin over the base of the cephalothorax.
b. No true lamellæ or translamella present.....**Pelops** Koch, 1835
[Type: *P. acromios* (Hermann)]
bb. Lamellæ, and frequently translamella present.....**Euplops** n. gen.
[Type: *Pelops uraceus* Koch]
aa. Abdomen without shelf-like expansion at its anterior margin, **Peloptulus**[5] Berlese, 1908
[Type: *Pelops phaeonotus* Koch]

[5]Erected as a subgenus by Berlese.

Key to the Genera of Subfamily Oribatinæ.

a. Pteromorphæ attached, or apparently attached, to both cephalothorax and abdomen.....Tribe TANEOPTERA

b. Abdomen circular, or almost circular, in outline, and bearing large setæ, **Neogymnobates** n. gen.
[Type: *N. multipilosus* (Ewing)]

bb. Abdomen very long, subcylindrical; either hairless, or bearing small setæ.

c. Sides of cephalothorax and of abdomen somewhat swollen so that they are not parallel; femora II without expansions..**Gymnobates** Banks, 1902
[Type: *G. glaber* Banks]

cc. Sides of cephalothorax and abdomen subparallel; femora II with blade-like expansions.....**Oripoda** Banks and Pergande, 1910 (?)
[Type: *O. elongata* Banks and Pergande]

aa. Pteromorphæ attached to abdomen only.

b. Pteromorphæ not truncate in front; extending beyond the anterior margin of abdomen.....Tribe MACROPTERA

c. Pteromorphæ continuous with dorsal plate, not hinged to abdomen.

d. Pteromorphæ not extending downward from the place of their insertion, but projecting forward along the sides of cephalothorax, **Tenuiala** Ewing, 1913
[Type: *T. nuda* Ewing]

dd. Pteromorphæ extending downward as well as forward from the place of their insertion.....**Achipteria** Berlese, 1885
[Type: *Oribata nicoletii* Berlese]

cc. Pteromorphæ not continuous with dorsal plate, but hinged to it in such a manner that they can be folded down over the ventral surface of the body.....**Oribata**[6] Latreille, 1802
[Type: *Notaspis alatus* Hermann]

bb. Pteromorphæ usually truncate, not extending beyond the anterior margin of the abdomen.....Tribe BRACHYPTERA

c. Pteromorphæ united by a transverse shelf-like expansion from the anterior margin of abdomen.....**Jugatala** Ewing, 1913
[Type: *J. tuberosa* Ewing]

cc. Pteromorphæ not united by a shelf-like expansion from the abdomen.

d. Cephalothorax completely covered by a roof-like projection from its line of junction with the abdomen.....**Tegoribates** n. gen.
[Type: *T. subniger* Ewing]

dd. Cephalothorax not covered by any roof-like projection from the line of its junction with the abdomen.

e. Lamellæ attached to cephalothorax along a part, or the whole of their inner borders.

f. Either translamella present, or the lamellæ joined to each other in front.

g. Pteromorphæ not rudimentary (cusp-like, or shelf-like).

h. Integument rough, being either tuberculate or corrugated. **Eremaeozetes** Berlese, 1913
[Type: *E. tuberculatus* Berlese]

hh. Integument not rough, although it may be finely punctate.

i. Translamella blade-like, or lamellæ joined in front.

j. Two pairs of lamellæ present, also tectopedia for legs II, **Sphaerozetes** Berlese, 1885
[Type: *Oribates orbicularis* Koch]

jj. A single pair of lamellæ present, tectopedia for second pair of legs absent.....**Podoribates** Berlese, 1908
[Type: *Oribates longipes* Berlese]

ii. Translamella a mere ridge.....**Protoribates** Berlese, 1908
[Type: *Oribates dentatus* Berlese]

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[6]Oudemans and Banks use *Galumna* instead of *Oribata*, or *Oribates*, for this genus, holding that the *Notaspis alatus* Hermann is not a true *Oribata*. The writer prefers to follow Michael and others, believing it to belong to *Oribata*.

gg. Pteromorphæ rudimentary, shelf-like.....**Neoribatula** n. gen.
[Type: *N. brevisetosa* (Ewing)]

ff. Translamella absent, but lamellæ sometimes joined by a line (not by a ridge).

g. Tarsal claws monodactyle.

h. Integument rough, or pitted.....**Tegeozetes** Berlese, 1913
[Type: *T. tunicatus* Berlese]

hh. Integument smooth.....**Oribatodes** Banks, 1895
[Type: *O. mirabilis* Banks]

gg. Tarsal claws tridactyle.

h. Pteromorphæ rudimentary, or shelf-like, **Oributula** Berlese, 1896
[Type: *O. tibialis* (Nicolet)]

hh. Pteromorphæ not rudimentary.

i. Integument of dorsum smooth.....**Ceratozetes** Berlese, 1908
[Type: *Oribates gracilis* Michael]

ii. Integument rough, reticulate, or pitted.

j. No hairs on abdomen..... **Trachyoribates** Berlese, 1908
[Type: *Oribates ampulla* Berlese]

jj. Conspicuous hairs on abdomen...**Peloribates** Berlese, 1908
[Type: *Oribates peloptoides* Berlese]

ee. Lamellæ attached to cephalothorax at their bases only, very large.

f. Lamellæ entirely free from each other.....**Oribatella** Banks, 1895
[Type: *O. 4-dentata* Banks]

ff. Lamellæ united or joined together for much of their length,
Joelia Oudemans, 1906
[Type: *Oribates fiorii* Coggi]

Family NOTHRINÆ.

Subfamily Serrariinæ has but one Genus.....**Serrarius** Michael, 1883
[Type: *S. microcephalus* (Nicolet)]

Subfamily Zetorchestinæ has but one Genus.....**Zetorchestes** Berlese, 1888
[Type: *Z. micronychus* (Berlese)]

Key to the Genera of Subfamily Notaspidinæ.

a. Legs inserted well under the body; abdomen strongly arched,
Liacarus[7] Michael, 1898
[Type: *L. simile* (Nicolet)]

aa. Legs inserted at the edges of the body; abdomen not so strongly arched.

b. Lamellæ seldom more than half as long as the cephalothorax and being low blade-like, or ridge-like structures.

c. Lamellæ placed well toward the median plane and running together in front.....**Cultroribula** Berlese, 1908
[Type: *Notaspis juncta* Michael[8]]

cc. Lamellæ, which may be vestigial, placed more laterally, not running together in front, although they may be connected with a translamella,
Lucoppia Berlese, 1908
[Type: *Zetes lucorum* Koch]

bb. Lamellæ very long and narrow, about as long as the cephalothorax, lance-like and provided with cusps in front.

c. Lamellæ attached to cephalothorax for their whole length, except for the small cusp; abdomen somewhat truncate in front, **Conoppia** Berlese, 1908
[Type: *Oppia microptera* Berlese]

cc. Lamellæ attached to cephalothorax for about one-half their length; abdomen circular.....**Notaspis** Hermann, 1804
[Type: *N. bipilis*[9] Hermann]

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[7] = *Liosoma*, which name was found to be preoccupied by Michael.

[8] This species was suggested by Michael in his "British Oribatidæ" as the type of *Notaspis* Hermann, but the type of *Notaspis* Hermann, was fixed by Nicolet in 1854, hence *Zetes lucorum* Koch is available as a type for *Lucoppia* Berlese.

[9] Not *Zetes lucorum* Koch.

Key to the Genera of Subfamily Tegeocraninæ.

a. Cephalothorax and abdomen joined above by a chitinous shield common to both.....**Scutovertex** Michael, 1879
[Type: *S. sculptus* Michael]

aa. Cephalothorax and abdomen not joined by a chitinous shield common to both.

b. Ungues tridactyle.

c. Tibiæ of legs not swollen or pedicellate.

d. Pseudostigmatic organs projecting out of the pseudostigmata.

e. Lamellæ very large, extending forward for almost the whole length of cephalothorax; translamella absent.....**Cepheus** Koch, 1835
[Type: *C. minutus*[10] Koch]

ee. Lamellæ low chitinous bars, united by a translamella,
Chaunoproctus Pearse, 1906
[Type: *C. cancellatus* Pearse]

dd. Pseudostigmatic organs sunk into the pseudostigmata,
Ommatocepheus Berlese, 1913
[Type: *Cepheus ocellatus* Michael]

cc. Tibiæ of the legs somewhat pedicellate and swollen,
Banksia[11] Voigts and Oudemans, 1905
[Type: *Notaspis tegeocranus* Hermann]

bb. Ungues monodactyle.

c. Lamellæ blade-like.

d. Cephalothorax separated from abdomen above by the unbroken anterior border of the latter.....**Tegeocranus** Nicolet, 1855
[Type: *T. coriaceus* (Koch)]

dd. Cephalothorax not completely demarcated from abdomen dorsally, because of the incomplete anterior border of the latter,
Tectocepheus Berlese, 1896
[Type: *T. velatus* (Michael)]

cc. Lamellæ low solid ridges.....**Carabodes** Koch, 1835
[Type: *C. femoralis* (Nicolet)]

Key to the Genera of Subfamily Damaeinæ.

a. Cephalothorax separated from abdomen dorsally by the complete anterior border of the latter.

b. Claws of all the tarsi monodactyle.

c. Abdomen circular or subcircular in outline; genital and anal openings usually close together.

d. Integument of dorsum of abdomen smooth.....**Damaeus** Koch, 1835
[Type: *D. geniculatus* (Linn.)]

dd. Integument of dorsum of abdomen rough, frequently reticulate.
Eremella Berlese, 1913
[Type: *E. vestita* Berlese]

cc. Abdomen oval, longer than broad; genital and anal openings usually separated from each other by a considerable distance.

d. Cheliceræ stout, strongly chelate.

e. Integument of dorsum smooth; larger forms..**Dameosoma** Berlese, 1892
[Type: *D. denticulatum*[12] (Canestrini, G. & R.)]

ee. Integument of dorsum rough (coarsely granular or tuberculate); smaller forms.....**Dameolus** Paoli, 1908
[Type: *D. asperatus* (Berlese)]

dd. Cheliceræ styliform.....**Suctobelba** Paoli, 1908
[Type: *S. trigona* (Michael)]

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[10]Not *C. tegeocranus* (Hermann), or *C. latus* Koch.

[11]Name suggested in 1905 by Voights and Oudemans to replace *Kochia* Oudemans, 1900, which was found to be preoccupied. *Kochia* was suggested by Oudemans to replace *Cepheus* Koch, because the type of the old genus *Cepheus, C. latus* Koch, did not belong to the genus in question.

[12]Named by Paoli to replace the *D. concolor* of Berlese, which was found to be different from the *D. concolor* (Koch).

bb. Claws of the tarsi of the first three pairs of legs monodactyle, of the fourth pair tridactyle.....**Heterobelba** Berlese, 1913
[Type: *H. galerulata* Berlese]

bbb. Claws of all the tarsi tridactyle.

c. Pseudostigmatic organs foliaceous, or flabelliform,
Licneremaeus Paoli, 1908
[Type: *Notaspis licnophora* Michael]

cc. Pseudostigmatic organs not foliaceous or flabelliform.

d. Dorsal integument pitted or reticulate; second pair of legs about as long as others.

e. Tectopedia well developed; dorsal integument of abdomen pitted; hairs of abdomen long, flexible, pectinate,
Tricheremaeus Berlese, 1908
[Type: *Notaspis serrata* Michael]

ee. Tectopedia absent or rudimentary; dorsal integument of abdomen reticulate; hairs of abdomen simple.....**Micreremus** Berlese, 1908
[Type: *Eremaeus brevipes* Michael]

dd. Dorsal integument smooth; second pair of legs shorter than the others,
Heterodamaeus n. gen.
[Type: *Damaeus bicostatus* Koch]

aa. Border between cephalothorax and abdomen incomplete dorsally toward the median line so that the two parts of the body run together here,
Amerus Berlese, 1896
[Type: *A. troisi* (Berlese)]

Key to the Genera of Subfamily Nothrinæ.

a. Abdomen as a whole convex, or arched, above.

b. Dorsal plate of abdomen not fully chitinized; adults carrying cast nymphal skins arranged so as to form concentric areas at different levels,
Neoliodes[13] Berlese, 1888
[Type: *N. theleproctus* (Hermann)]

bb. Dorsal plate of abdomen fully chitinized; adults without cast nymphal skins.

c. Abdomen without lateral excretory tubes.

d. No seta-bearing tubercules on dorsum of abdomen,
Hermannia Nicolet, 1855
[Type: *H. picea* (Koch)]

dd. Mammæ-like, seta-bearing tubercles on dorsum of abdomen,
Masthermannia Berlese, 1913
[Type: *M. mammillaris* (Berlese)]

cc. Abdomen with a pair of lateral excretory tubes projecting some distance from the surface of the body wall.....**Hermanniella** Berlese, 1908
[Type: *H. granulata* (Nicolet)]

aa. Abdomen as a whole not convex above, but flat, concave, or undulating.

b. Abdomen oval in outline, except for the anterior border.

c. Tarsal claws monodactyle.....**Heminothrus**[14] Berlese, 1913
[Type: *Nothrus targionii* Berlese]

cc. Tarsal claws tridactyle.

d. Abdomen with a broad margin above differently marked from a central area.....**Cymbaeremaeus** Berlese, 1896
[Type: *Eremaeus cymba* Nicolet]

dd. Abdomen without a differentiated band or margin above,
Eremaeus Koch, 1842
[Type: *E. oblongus* Koch.]

bb. Abdomen rectangular, or trapezoidal in outline.

c. Abdomen with two large lateral lobes extending backward from its posterior margin.....**Uronothrus**[15] Berlese, 1913
[Type: *Nothrus segnus* (Hermann)]

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[13] = *Liodes* Hermann, which name was found by Berlese to be preoccupied.
[14] Suggested as a subgenus by Berlese in 1913.
[15] Erected as a subgenus by Berlese.

cc. Abdomen without posterior lobes.
d. Abdomen with prominent marginal seta-bearing tubercles, sometimes only behind.....**Nothrus** Koch, 1835
[Type: *N. spiniger* Koch]
dd. Abdomen without seta-bearing tubercles.....**Gymnonothrus** n. gen.
[Type: *Nothrus sylvestris* Nicolet]

Key to the Genera of Subfamily Lohmanninæ.

a. Abdomen subcylindrical; tarsal claws either monodactyle or bidactyle.
b. Tarsal claws monodactyle.....**Lohmannia**[16] Michael, 1898
[Type: *L. paradoxa* (Haller)]
bb. Tarsal claws bidactyle.....**Eulohamannia**[17] Berlese, 1910
[Type: *E. ribagai* Berlese]
aa. Abdomen oval, not cylindrical; tarsal claws tridactyle.
b. Abdomen never divided by a transverse suture above; integument tuberculate; claws homodactyle.....**Tumidalvus**[18] Ewing, 1908
[Type: *T. americana* Ewing]
bb. Abdomen sometimes divided above by a transverse suture; integument not tuberculate; claws sometimes heterodactyle,
Trhypochthonius Berlese, 1904
[Type: *T. tectorum*, Berlese]

Family HYPOCHTHONIDÆ.

Key to the Genera of Subfamily Hypochthoninæ.

a. Abdomen divided into two parts dorsally by a transverse suture.
b. Tarsal claws tridactyle; cephalothorax truncate in front,
Parhypochthonius Berlese, 1904
[Type: *P. aphidinus* Berlese]
bb. Tarsal claws mondactyle.
c. Abdomen spherical; dorsal surface tessellated,
Sphaerochthonius Berlese, 1910
[Type: *S. splendidus* (Berlese)]
cc. Abdomen not spherical; dorsal surface not tessellated.
d. Abdomen clothed with leaf-like setæ; shoulders each with a seta-bearing tubercle.....**Malacoangelia** Berlese, 1913
[Type: *M. remigera* Berlese]
dd. Abdomen clothed with setiform hairs; shoulders without seta-bearing tubercles.....**Hypochthonius** Koch, 1835
[Type: *H. rufulus* Koch]
aa. Abdomen divided dorsally into three or more parts by transverse sutures.
b. Abdomen clothed with moderate simple setæ.
c. Integument of dorsum of abdomen reticulate; body short,
Brachychthonius Berlese, 1910
[Type: *B. brevis* (Michael)]
cc. Integument of dorsum of abdomen smooth; body long,
Arthrochthonius n. gen.
[Type: *A. pallidulus* (Koch)]
bb. Abdomen bearing some large (enormous) pectinate, foliaceous, or plumose setæ.
c. Body clothed with large, broad, leaf-like or fan-like setæ,
Pterochthonius[19] Berlese, 1913
[Type: *P. angelus* Berlese]

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[16] = the old *Michaelia*, which name was shown to be preoccupied by Michael.
[17] Erected as a subgenus by Berlese.
[18] Berlese claims, "Acari Nuovi," Manipulus VI, 1910, that my genus *Tumidalvus* is a synonym of his *Trhypochthonius*, 1904. I hold it to be distinct for reasons shown in the above key.
[19] Erected by Berlese as a subgenus.

cc. When leaf-like, or fan-like setæ present, they are confined to the abdomen.
d. Tarsi very long, slender; legs and cephalothorax clothed with simple setæ.....**Heterochthonius**[20] Berlese, 1910
[Type: *H. gibbus* Berlese]
dd. Tarsi short, stout; legs and cephalothorax clothed with pectinate setæ.....**Cosmochthonius** Berlese, 1910
[Type: *C. lanatus* (Michael)]
Subfamily Trizetinæ has but one Genus.....**Trizetes** Berlese, 1904
[Type: *T. pyramidalis* Berlese]

Family HOPLODERMATIDÆ.

Key to the Genera of Subfamily Protoplophorinæ.

a. Claws of tarsi monodactyle.....**Protoplophora** Berlese, 1910
[Type: *P. palpalis* Berlese]
a. Claws of tarsi bidactyle, heterodactyle, and of enormous length,
Arthroplophora Berlese, 1910
[Type: *A. paradoxa* Berlese]
Subfamily Mesoplophorinæ has but one Genus.....**Mesoplophora** Berlese, 1904
[Type: *M. michaeliana* Berlese]

Key to the Genera of Subfamily Hoplodermatinæ.

a. Ungues monodactyle; anal and genital covers separate.
b. Cephalothorax with a median, dorsal carina.
c. Abdomen with a hood-like projection extending forward from its anterior margin.....**Steganacarus** n. gen.
[Type: *Hoplophora anomala* Berlese]
cc. Abdomen without hood-like projection extending forward from its anterior margin.
d. Abdomen as well as cephalothorax with a median carina above,
Tropacarus n. gen.
[Type: *Hoplophora carinatum* Koch]
dd. Abdomen without dorsal, median carina...**Hoploderma**[21] Michael, 1898
[Type: *H. magna* (Nicolet)]
bb. Cephalothorax without a median carina above.
c. Integument rough, pitted, or sculptured.....**Atropacarus** n. gen.
[Type: *Hoplophora stricula* Koch]
cc. Integument smooth, without pits or sculptures....**Ginglymacarus** n. gen.
[Type: *G. dasypus* (Duges)]
aa. Ungues tridactyle; anal and genital covers fused.
b. Integument rough, pitted, or sculptured.....**Euphthiracarus** n. gen.
[Type: *E. flavus* (Ewing)]
bb. Integument smooth, not pitted or sculptured....**Phthiracarus**[22] Perty, 1841
[Type: *Hoplophora ardua*[23] Koch]

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[20]Although given by Berlese as a subgenus, I hold that the characters are good generic ones.

[21]Name suggested by Michael to replace Hoplophora, which was found to be preoccupied.

[22]= *Tritia* Berlese.

[23]Michael claims that Koch's *Hoplophora decumana* is only a synonym of *Hoploderma dasypus* Duges, hence is not included in *Phthiracarus*. I suggest *Hoplophora ardua* Koch as the type of *Phthiracarus*.

DESCRIPTIONS OF NEW GENERA HERE PROPOSED.

Genus **Eupelops**[24] n. gen.

With the characters of the subfamily **Pelopinæ.** A chitinous hood-like projection extends forward from the anterior margin of the abdomen, which may be narrow, or again quite broad, in the latter case frequently being quadrangular. This chitinous expansion usually unites the two pteromorphæ. Lamellæ present. Translamella present or absent.

Type species: *Pelops uraceus* Koch.

The type species for the genus *Pelops* Koch, *P. acromios* (Hermann), is without either lamellæ or translamella. This new genus is erected, therefore, to include many species which are like *P. acromios* (Hermann) in most respects, but do not have the cephalothorax nude above. Berlese's *Peloptulus*, 1908, includes species which are without the shelf-like projection from the anterior margin of abdomen. Three of our American species are included in *Eupelops: E. latipilosus* (Ewing), *E. minnesotensis* (Ewing), and *E. laticuspidatus* (Ewing).

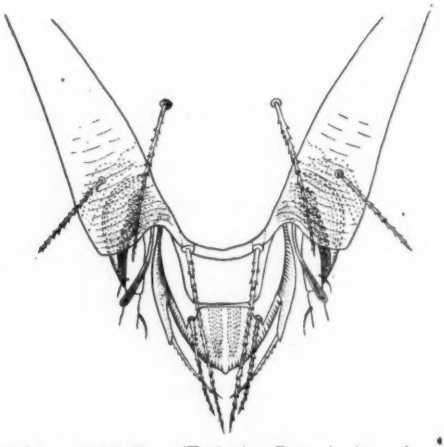

Fig. 1. *Neogymnobates multipilosa* (Ewing). Dorsal view of cephalothorax and anterior part of abdomen.

Genus **Neogymnobates**[25] n. gen.

With the characters of the subfamily **Oribatinæ**. Pteromorphæ attached to cephalothorax as well as to abdomen. Abdomen circular,

[24]From εὖ, good, well + *Pelops*.
[25]From νεος, new + *Gymnobates*.

or almost, in outline and bearing enormous setæ. Lamellæ present, blade-like. Translamella a chitinous ridge. A pair of lateral lamellæ present. Claws tridactyle.

Type species: *N. multipilosus* (Ewing). (See Fig. 1).

This genus is erected for a peculiar species described by the writer some years ago from specimens obtained in northern Illinois, not far from Chicago. At the time of collection I recognized that the species was quite different from other beetle mites, but hesitated in making it the type of a new genus. I regard this species, in a way, as a connecting link between the peculiar genus *Oripoda* Banks and Pergande and the other members of the subfamily *Oribatinæ*. It has the pteromorphæ of *Oripoda*, but the body of a true *Oribata*.

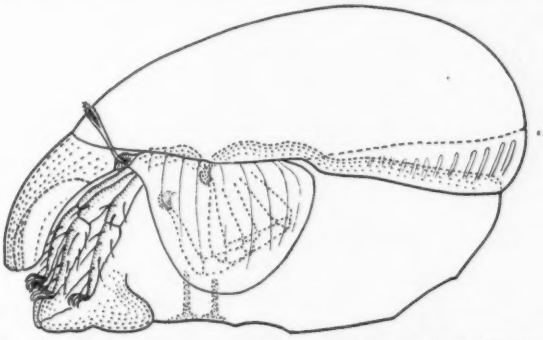

Fig. 2. *Tegoribates subniger* n. sp. Side view of individual with its legs flexed.

Genus **Tegoribates**[26] n. gen.

With the characters of the subfamily **Oribatinæ.** Pteromorphæ attached to abdomen only, truncate in front, not extending far beyond the anterior margin of abdomen, and not united by a transverse lamella. Cephalothorax completely covered by a roof-like projection which arises from the line of junction between the cephalothorax and abdomen and extends forward almost to the tip of the former.

Type species: *T. subniger* n. sp.[27] (See Fig. 2).

The large roof-like or hood-like projection above the cephalothorax in this genus makes it unique among the beetle-mites, and for that matter unique among all the mites in this respect. The nearest approach to this condition is found in the genus

[26]Meaning a covered *Oribates*.

[27]The descriptions of this species has been sent away for publication in Part II of my series on "New Acarina."

Joelia Oudemans, where the very large lamellæ are joined together in front at the median plane; however, in the case of *Joelia*, this junction is not complete so that no roof-like structure is formed. The genus *Tegoribates*, however, appears to be more closely related to some of the other genera than to *Joelia* Oudemans.

Genus **Neoribatula**[28] n. gen.

With the characters of the subfamily **Oribatinæ.** Pteromorphæ very small, rudimentary, attached to the abdomen only, truncate in front, not extending beyond the anterior margin of abdomen, and not united by a transverse lamella. Cephalothorax not covered by a roof-like projection. Lamellæ attached to cephalothorax along most of their inner margins. Translamella present.

Type species: *N. brevisetosa* (Ewing). (See Fig. 3).

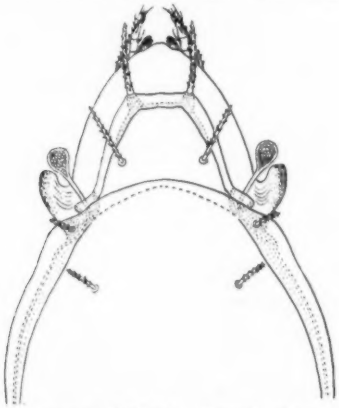

Fig. 3. *Neoribatula brevisetosa* (Ewing). Dorsal view of cephalothorax and anterior part of abdomen.

This genus is related to *Oribatodes* Banks and to *Oribatula* Berlese, but differs from both of these genera in having the translamella present and well developed.

Genus **Heterodamaeus**[29] n. gen.

With the characters of the subfamily **Damaeinæ.** Cephalothorax separated from abdomen dorsally by a complete anterior border of the latter. Tarsal claws all tridactyle. Pseudostigmatic organs not foliaceous or flabellate. Dorsal integument smooth. Second pair of legs shorter than others. Abdomen almost circular in outline, flat above.

Type species: *Damaeus bicosticus* Koch.

[28]From νεος, new + *Oribatula*.
[29]From ἕτερος, other than usual, different + *Damaeus*.

This genus is suggested to include some species of the old world and at least one from the new, *Damaeus magnisetosus* Ewing. Most of the species have the pseudostigmatic organs very long, the integument of the legs minutely tuberculate, while the tibiæ of the first pair of legs each bears above and distally a large tubercle from which a long tactile seta extends.

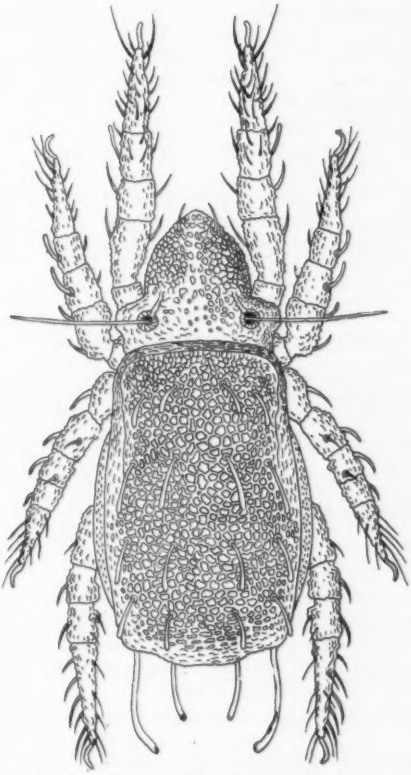

Fig. 4. *Nothrus sylvestris* Nicolet. Drawing made from a named specimen received from Michael.

Genus **Gymnonothrus**[30] n. gen.

With the characters of the subfamily **Nothrinæ.** Abdomen as a whole not convex above, but flat, concave, or undulating; rectangular or trapezoidal in outline. The abdomen is without large lobes behind, and also without seta-bearing tubercles.

Type species: *Nothrus sylvestris* Nicolet. (See Fig. 4).

[30]From γυμνός, naked + *Nothrus*.

This genus is erected to include the many nude species, which in the past have been placed in the genus *Nothrus*, but which differ markedly from the extreme and fantastic type species of that genus, *Nothrus spiniger* Koch.

Genus **Arthrochthonius**[31] n. gen.

With the characters of the subfamily **Hypochthoninæ.** Abdomen divided into three or more parts dorsally by transverse sutures, sides strongly depressed, shelf-like, clothed with moderate simple setæ. Integument of dorsum of abdomen smooth; body long, pyriform in outline. Cephalothorax without setæ above; pseudostigmatic organs very long; legs rather short; claws monodactyle.

Type species: *Hypochthonius pallidulus* Koch.

Erected to include many species related to those belonging to *Brachychthonius* Berlese, but having the body longer, the sides strongly depressed, and the integument smooth.

Genus **Steganacarus**[32] n. gen.

With the characters of the subfamily **Hoplodermatinæ.** Tarsal claws monodactyle; anal and genital covers separate. Cephalothorax provided with a median dorsal ridge or carina. Abdomen with a hood-like projection extending forward from its anterior margin.

Type species: *Hoplophora anomala* Berlese.

At least one of our North American species, *S. cucullatum* (Ewing), is included in this genus.

Genus **Tropacarus**[33] n. gen.

With the characters of the subfamily **Hoplodermatinæ.** Claws of tarsi monodactyle; anal and genital covers separate. Cephalothorax with a median carina above. Abdomen without hood-like projection extending forward from its anterior margin, but with a median carina above like the one on the cephalothorax.

Type species: *Hoplophora carinatum* Koch.

This genus is founded on this peculiar species of Koch's with the dorsal carina on both the abdomen and cephalothorax. I know of no American species which has these characteristics.

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[31]From *ἄρθρον*, joint + *Chthonius*.
[32]From *στεγανός*, covered + *Acarus*.
[33]From *τρόπις*, keel + *Acarus*.

Genus **Atropacarus**[34] n. gen.

With the characters of the subfamily **Hoplodermatinæ.** Tarsal claws monodactyle; anal and genital covers separate. Cephalothorax without a median carina above. Integument rough, pitted, or sculptured.

Type species: *Hoplophora stricula* Koch.

One of our American species, *A. illinoiensis* (Ewing), known to be included in this new genus. There may be others.

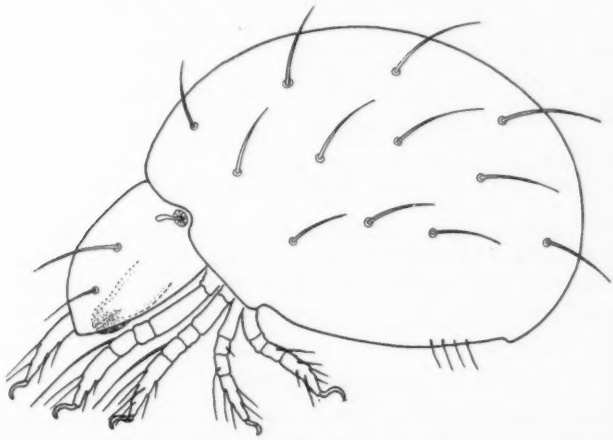

Fig. 5. *Ginglymarcarus dasypus* (Duges). Drawing made from a named specimen received from Michael.

Genus **Ginglymacarus**[35] n. gen.

With the characters of the subfamily **Hoplodermatinæ.** Tarsal claws monodactyle; anal and genital covers separate. Cephalothorax without a median carina above. Integument smooth, without pits or sculptures.

Type species: *G. dasypus* (Duges). (See Fig. 5).

In this genus we find in our country at least two species besides the type species. They are *G. sphaerula* Banks and *G. lurida* Ewing. The genus will be found to include many foreign species.

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[34]From a, not + τρόπις, keel + *Acarus*.
[35]From γίγγλυμος, hinge joint + *Acarus*.

Genus **Euphthiracarus**[36] n. gen.

With the characters of the subfamily **Hoplodermatinæ.** Ungues tridactyle; anal and genital covers fused. Integument rough, pitted or sculptured. (See Fig. 6).

Type species: *E. flavus* (Ewing).

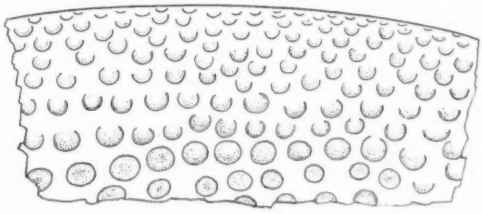

Fig. 6. *Euphthiracarus flavus* (Ewing). Side view of a section of the arched part of the abdomen to show nature of pitting.

This genus is suggested for the rough or pitted species of the old genus *Phthiracarus*. In this country I know of only one such species, the type. We have, however, about a dozen described species of the old genus *Phthiracarus*.

Acknowledgment.

Dr. J. W. Folsom, of the University of Illinois, aided the writer very materially in the preparation of this synopsis by offering him a laboratory in which to work and by helping secure some of the much needed literature.

[36]From εὖ, good, well + *Phthiracarus*.

SOME COLORADO SPECIES OF THE GENUS LACHNUS.

By C. P. GILLETTE.

Lachnus coloradensis, n. sp.

Adult Stem Mother.—General color black, with more or less rufous upon the head, thorax and legs; the anterior and nearly all of middle femora, the proximal portion of hind femora, and the basal portions of all tibiæ rusty brown, the hind tibiæ being black nearly to the base; all tibiæ black at extreme base; antennæ pale with distal ends of joints 3, 4 and 5 black. The black of the dorsum is mostly dull, but with polished lines running across between each two segments, and a larger polished area on joints 7 and 8. In some specimens there is somewhat of a rufous tinge over most of the dorsum; cornicles black, mammiform, terminating in a slightly projecting nipple; cauda scarcely apparent; vertex prominent and convex. Length of body 4.25; antenna 1.90. Joints of antenna: III, .50; IV, .26; V, .30; VI, .23; hind tibiæ, 3.10; beak attaining hind margin of third abdominal segment; sternum and first two abdominal segments rusty brown; head small, convex in front; one sensorium near distal ends of joints 3, 4 and 5, besides the permanent one on joint 5, and sometimes there are two on joint 4. (See Plate X, figures 1-3).

The young of the second generation are pale gray with dusky green upon dorsum of head and in the region of the cornicles, the thoracic segments being nearly white, and the abdomen dusky to brownish. (See figure 4.)

Apterous Viviparous Female.—General color black or blackish, somewhat shining, especially below; head, thorax, coxæ and basal portions of femora and tibiæ more or less rufous; antennæ pale with distal ends of joints black; terminal joint all black; shape of abdomen varying from broad oval to rather elongate. Length of antenna 2; joints proportioned as follows: 7 : 6 : 43 : 22 : 25 : 14; sensoria as in stem mother, except that there are usually two sensoria on joint 4; rostrum nearly attaining tip of abdomen; cornicles mammiform, small, about .40 across mammiform base; hind tibiæ very long and curved.

This form resembles the fundatrix so closely it was not thought necessary to draw it. Antenna shown in figure 5.

Winged Female of Second Generation.—Color rusty yellow to yellowish brown; cornicles, genital plates, mesosternum, coxæ, distal half of beak, joint 6 and distal ends of joints 3, 4 and 5 of antennæ, all of the tarsi, distal ends and very short proximal ends of all tibiæ (fully four-fifths of hind tibiæ), distal ends of all the femora, eyes and stigmas, black or blackish. The distal ends of middle and front femora may be only dusky; beak attaining 8th abdominal segment; dorsal surface slightly pulverulent; upon the pronotum there is a diagonal lateral line upon either side; there is a V-shaped white mark near the middle of the anterior margin and one near the posterior margin of the mesothorax and a white line near insertion of either front wing. The scutellum is more or less powdered, as is the metathorax, and transverse white dashes and lateral spots upon 3rd and 4th abdominal segments. See Plate X, figures 6 to 10.

Apterous Oviparous Female.—Prevailing color cinnamon brown to brownish black, shining, with head and pro- and meso-thorax a sordid pale yellowish green to light brown; beneath, pale greenish yellow, darker posteriorly and at lateral margins of abdomen; a heavy covering of white secretion upon the tergum and pleuræ of the abdomen back of the cornicles to the terminal segment, which is exposed; cornicles black, moderate in size of basal enlargement; antennæ with tips of joints 3, 4 and 5 and all of 6 black; beak nearly attaining the tip of the abdomen; form rather elongate; legs colored as in apterous viviparous female; hind tibiæ, with many small sensoria; hind legs very short; tibiæ but little swollen; length of body 3; antenna, 1.50; joints: III, .51; IV, .28; V, .29; VI, .20; hind tibiæ, 2.50. See figures 11-13.

Eggs.—They are deposited in single rows on the upper surface of the needles and are covered with a rather coarse, waxy material from the abdomen of the oviparous female. As soon as an egg is deposited, the female rubs her hind tarsi in the waxy secretion on her abdomen and then rubs them over the egg and continues this process till the latter is well covered with the short, broken bits of wax as shown in figure 14.

Alate Male.—Described from alcoholic material taken by Mr. L. C. Bragg from Engelmann spruce at Fort Collins, Colorado, November 9, 1906, along with the oviparous ♀ ♀.

Black parts, proportions of antennal segments, and cornicles as in alate viviparous ♀; length of body about 2.70; wing, 3.90; antenna, 1.45; hind tibia, 2.12; sensoria of antennæ numerous on joints 3 to 6, circular in form and varying much in size. The numbers upon the segments run about as follows: III, 18; IV, 14; V, 18; VI, aside from the rather scattered cluster of small sensoria about the permanent one, there is 1 or 2 on the basal half. See figure 15.

This is a common species upon Engelmann and blue spruces in Northern Colorado, which we have been taking for the past eight years. It is a bark feeder and has always been found by us attacking small limbs where the lice insert their beaks in the crevices of the bark. As in other species treated in this paper, the color markings of the young lice are very distinctive.

Our accessions records for this species are as follows:

Fundatrix	Ft. Collins,	Colo.,	April 20, '08,	C. P. Gillette,	*Picea parryana*
	"	"	April 20, '08,	L. C. Bragg,	" "
	"	"	April 21, '08,	C. P. Gillette,	" "
Alate and apterous viviparous females	"	"	..... '00,	C. P. Gillette,	" "
	"	"	May 4, '08,	C. P. Gillette,	" "
	"	"	May 12, '08,	C. P. Gillette	" "
	"	"	May 23, '08,	Miriam A. Palmer	" "
	"	"	May 25, '08,	C. P. Gillette,	" "
	"	"	June 6, '11,	L. C. Bragg,	" "
	Ward,	"	July 17, '09,	L. C. Bragg	" "
	Tolland,	"	July 25, '13,	Ellsworth Bethel,	englemanni
Oviparous Female	Ft. Collins,	"	Sept. 1, '06,	L. C. Bragg,	"
	"	"	Oct. 6, '09,	O. G. Babcock,	"
	"	"	Nov. 10, '14,	L. C. Bragg	"
	"	"	Nov. 14, '10,	L. C. Bragg,	"
	"	"	Nov. 9, '06,	L. C. Bragg,	"
♂	"	"	Nov. 9, '06,	L. C. Bragg,	*Picea parryana*

***Lachnus palmeræ,** n. sp.

Stem Mother, First Instar.—General color ashy gray, due to a fine white powder which covers the body; eyes, tips of antennæ and beak, and the cornicles, black or blackish; a dusky to blackish transverse band, usually interrupted for some distance in the middle, upon the first abdominal segments; upon either side of the prothorax, an oblique, impressed dark line; and extending over the abdomen about six rows of small impressed dark spots. A very narrow median dorsal dark line is usually quite distinct and is due to the absence of the white powder. Antennæ, legs and body rather hairy; antennæ with four joints, the third being more than half of the antenna in length; fourth joint terminated by a short conical spur. As the lice grow in this instar the white powder increases in amount. At base of the spur is a single prominent sensorium. Length about 1.35.

The young lice, upon hatching, cluster on the bark of the twigs to insert their beaks and feed. See figure 16.

Described from specimens taken on a small Engelmann spruce on the college campus, March 17, 1910.

Adult Stem Mother.—The general color is a dark sordid brown, in some examples almost black; all of the lice conspicuously marked with gray or whitish lines and spots; a black transverse band, which is broken at the middle, extends across the first segment of the abdomen to the lateral margins; in front of this are black or dusky splashes upon the segments of the thorax, making two broken black bands extending to the head; the first and last joints of the antennæ, the distal ends of joints 4 and 5, the eyes, all of the tarsi, the coxæ, the knees, the distal ends of the tibiæ and their extreme bases, the cornicles and beak and the genital plates, black or blackish. From the head to the tip of the abdomen upon the dorsum is a narrow gray line on either side of which are broken transverse gray lines about one to each segment, and all about the same width as the median line, and in most instances, in two pieces, on either side of the median line. The head is light rusty brown, more or less covered with white powder; the antenna and the greater portion of the femora and tibiæ, are pale yellowish or sordid white in color. The cornicles are large, broad at the base, moderately elevated and mammiform in shape, and the beak reaches to the hind margin of the third segment of the abdomen; legs, antennæ and entire body, rather thickly set with slender hairs; head small, quite convex in front and usually distinctly bi-lobed; cauda not apparent. Length of body, 3.75 to 4 (balsam spec. 3 to 3.50) by 2.40 wide; length of antenna 1.30; joints: III, .45; IV, .20; V, .23; VI, (with spur) .17, with little variation. See figures 16a to 19.

Apterous Viviparous Female.—In general appearance and markings like the stem mother. No figures.

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*I take pleasure in dedicating this species to Miss Miriam A. Palmer, not merely because she made the drawings for this and other aphid papers, but because she takes a keen and intelligent interest in everything scientific, and especially in the Aphides, and our friends, their enemies, the *Coccinellidæ*.

Young.—About one-third grown. Taken by the writer April 25, 1908. The meso- and meta-thorax are quite light and somewhat pinkish or flesh colored; the abdomen is dusky brown, but spotted with white pulverulence much after the pattern of the adult, and especially is this true of specimens about half grown; the head and abdomen are conspicuously darker than the thorax, usually almost black, with four conspicuous white blotches, two lateral, about midway of the abdomen, and two on the median line, one at the meta-thorax and the other at the extreme tip. The posterior half of the prothorax is also black except upon the middle portion. See figure 20. The beak of very young lice is nearly twice the length of the body. See figure 16.

Winged Female of Second Generation.—Described from specimens bred in the laboratory on sprigs of blue spruce, May 11, 1908.

General color of body, blackish; a rather conspicuous median white stripe begins on the vertex of the head and extends to the middle of the mesothorax. A continuation of this stripe appears as a white dash upon the middle of the scutellum and as white spots upon the median dorsal line of the abdomen. Upon either side of this row of dots upon the abdomen is another similar row, making three rows of white spots or dashes extending to the region of the cornicles. Back of the cornicles there is also more or less of a white powdery secretion appearing either as spots or transverse lines. On the scutellum the white may extend laterally so as to almost entirely cover this part. There is also some of this white powder along the lateral margins of the thorax beneath the wings, and upon the sides of the abdomen in front of the cornicles, and also behind and beneath these organs. The whole ventral surface is more or less spotted with white. Joints 1, 2 and 6 and the distal ends of joints 3, 4 and 5 of the antennæ, are black; all of the tarsi, the distal ends of all the femora and tibiæ, and the coxæ are black; the remaining parts of the legs and the antennæ are very pale yellow. The cornicles are very large and black; genital plates and eyes black; beak whitish to the middle, the distal one-half being black or blackish, and reaching to the eighth abdominal segment; wings of medium length, stigma long, black, narrow and parallel sided; stigmal vein straight; the whole surface of the body, including legs and antennæ, thickly set with fine hair; eyes very prominent; ocular tubercles very small; hind tibiæ black for fully one-half their length, and all of the tibiæ having a short black portion at the proximal end; beak surpassing cornicles. Sensoria rather indistinct and variable in number and distributed about as follows: On distal one-half of third joint, 3 to 5; fourth joint, 1 to 3; fifth joint, 2 to 3; cornicles about .30 high by .40 broad at base, mammiform. Length of antennæ about 1.30; joints I and II of antennæ together .24; III, .54; IV, .26; V, .27; VI, .18; length of body, 3.50; wing, 4.50; hind tibiæ, 2.50. The general color when placed in alcohol is a light yellowish brown. The third transverse vein with its branches is much more slender than the first and second stigmal veins. See figures 21-23.

Figure 22, Plate I, was drawn from an antenna plainly showing seven sensoria on Joint III, but 3 to 5 were all that could be seen in other examples.

Oviparous Female.—Differs from the stem ♀ in general appearance in being more slender in form, having the white markings much heavier, and especially in having the head and all the abdomen back of the cornicles, except the anal plate, white. The hind tibiæ are thickly set with sensoria throughout their length. Length of body 4; antenna, 1.15; ratio of joints beyond the second—30 : 14 : 16 : 13 (with spur). See figures 24 to 27.

The eggs are yellowish brown when laid and measure 1.30 millimeters in length. They soon turn black in the daylight and are deposited mostly on the bark of the twigs at the bases of the needles, but sometimes are placed upon the needles also. See figures 24 to 28.

Alate Male.—The males resembles the alate viviparous ♀, but are much smaller, about 2.30 long, and more slender; the white markings are lighter and the black markings upon the antennal segments are absent, or nearly so. Joints 3, 4 and 5 of the antenna have many tuberculate sensoria irregularly distributed throughout their lengths; about 50 may be counted on joint III, about 15 on IV, and about 6 on V. Ratio of joints beyond second about as follows: 20 : 10 : 12 : 7 (with spur).

Described from examples taken on blue spruce, Ft. Collins, Colo., October 14, 1910, by L. C. Bragg, and from *Picea Engelmanni*, Fort Collins, 10-6, '09, by O. G. Babcock. See figures 29 and 30.

This is a very common species on the blue spruce in the vicinity of Fort Collins, Colorado, and is altogether a bark feeder attacking the small limbs.

Our Collection records are as follows:

Young Fundatrix	Ft. Collins,	Colo.,	Mar. 16, '10,	M. A. Palmer,	*Picea engelmanni*
	"	"	April 21, '08,	C. P. Gillette,	" *parryana*
Adult Fundatrix	"	"	April 20, '08,	L. C. Bragg,	" "
	"	"	April 21, '08,	C. P. Gillette,	" "
	"	"	April 24, '08,	M. A. Palmer,	" "
	"	"	April 25, '08,	C. P. Gillette,	" "
Apterous and Alate Viviparous Females	"	"	May 4, '08,	C. P. Gillette,	" "
	"	"	May 5, '08,	C. P. Gillette,	" "
	"	"	May 11, '08,	C. P. Gillette,	" "
	"	"	May 12, '08,	C. P. Gillette,	" "
	"	"	May 12, '10,	L. C. Bragg,	" "
	"	"	May 16, '10,	L. C. Bragg,	" "
	"	"	May 18, '12,	L. C. Bragg,	" "
	"	"	May 20, '12,	L. C. Bragg,	" "
	"	"	June 2, '06,	L. C. Bragg,	" "
Oviparous Female	"	"	Oct. 6, '09,	O. G. Babcock,	" *englemanni*
	"	"	Nov. 11, '11,	L. C. Bragg,	" *parryana*
Male.....	"	"	Oct. 14, '10,	L. C. Bragg,	" "
	"	"	Oct. 17, '10,	L. C. Bragg,	" "
	"	"	Oct. 21, '09,	L. C. Bragg,	" *engelmanni*
	"	"	Oct. 22, '09,	L. C. Bragg,	" "

Lachnus braggii, n. sp.

Taken feeding upon the bark of the twigs of Colorado blue spruce, *Picea parryana*, only.

Stem Mother.—Almost completely covered with a white pulverluence, but over the dorsum there are many spots and transverse broken bands where the white powder is not present and where the dusky brown to black color of the body can be seen. The cornicles are dark brown or blackish in color, quite small, and not very much elevated above the surface. The legs except the tips of the tibiæ and the tarsi; and the antennæ, except the extreme tips, are light amber in color. The eyes and genital plates are black, and the ventral surface of the body is covered with a light gray pulverulence. Joint 6 and distal end of 5 of the antenna, black or blackish; length of body from 3.20 to 3.70; width 2.40 to 2.50; length of antennal joints: III, .40; IV, .17; V, .21; VI, .17; whole length, 1.10; joints 4, 5 and 6 usually with one sensorium each besides the permanent ones on 5 and 6. When placed in balsam, there is a broken line of black extending from the prothorax to the first segment of the abdomen on either side of the median line. The two lines are made by a pair of black blotches upon the dorsum of each thoracic segment; a row of small black dots lies outside of these near each margin. The body is covered with a very fine, but rather long, pubescence which occurs also upon the joints of the antennæ and upon the legs. The length of the hind tibiæ is 1.60 to 1.70; beak short, but little surpassing the hind coxæ. See Plate XI, figures 1 to 4.

Apterous Viviparous Female, Second Generation.—Body covered with white pulverulence as in case of the stem mother; color also the same throughout. Length of body 3.75; width 2.40; antennal joints: III, .46; IV, .18; V, .23; VI, .17; length of antenna, 1.17; cauda appearing as a short broad lobe, convex on the posterior margin, and slightly upturned; beak just surpassing the 2d coxæ; head very small, quite convex on the frontal margin, not bi-lobed; sensoria of antenna rather indistinct and about as follows: III, 0; IV, .1 or .2; V, .2; VI, with terminal cluster. See figure 5.

Young of Third Generation, before first moult, pale amber in color, with a light covering of white pulverulence, and the head rather conspicuously dark dusky brown. Down the dorsum is a double row of small naked spots that appear a little darker than the general surface. The cornicles appear as little black dots and the genital plates and tarsi are dusky brown. See figure 6.

Winged Female, Third Generation.—Reared in the laboratory from the same colony from which the stem mother was described.

The ground color is pale to dark yellowish brown, or, in light examples, a sordid white. Head and thorax above, blackish or dark chocolate brown, rather heavily powdered with white; eyes and cornicles black, as are also the tarsi, and distal ends of all the tibiæ, the genital plates, the stigma of the wings, the last joint of the antennæ and very short distal rings upon joints 3, 4 and 5. The abdomen may be almost entirely white, due to the white powder which covers the body, or there may be very distinct white transverse bands separated by a somewhat

darker portion which exposes the yellowish color of the abdomen beneath. On the under surface, the color is pale yellowish, more or less heavily powdered everywhere with white. The distal ends of the femora are dusky brown, or, in some specimens, almost black, especially the hind pair. The cornicles are very small as in the apterous stem mother; hind tibiæ short, stigma of wing long and narrow and almost parallel sided; length of body, 2.75; length of wing, 3.70; cauda short and very broad and oval on the posterior margin, which is black; antenna, 1.14; hind tibia, 1.60; beak, 1.54; cornicles mammiform, smaller than in *palmeræ*, about .11 high by .14 broad at the base; joints of antennæ about as follows: III, .44; IV, .19; V, .23; VI, .17; sensoria of the antennæ about as follows: III, 1; IV, 1; V, 2; VI, usually 1 or 2 small ones a little below the large terminal one; entire surface of the body, including antennæ, thickly set with long delicate hairs. See figures 7 to 10.

In alcohol, the general color is pale yellow and the dorsum of the abdomen is sprinkled with black specks and dashes.

Oviparous Female.—General body color pale yellow, covered everywhere with white powder; form rather robust; thorax and segments 3 and 4 of the abdomen with broken transverse bands or dashes, and a rather distinct transverse blackish band upon the fifth segment of the abdomen between the cornicles; upon the other segments black patches only are to be found. The cornicles are black, as are the eyes, distal 2 or 3 joints of the antennæ, the tarsi, the extreme tip of the abdomen above, the hind tibiæ and the distal ends of all the femora and the middle and anterior tibiæ and coxæ; cornicles rather small. When the white powder is removed, the head and two anterior segments of the thorax are dark brown in color; length of body, 3.45; width, 2; length of antenna, 1.57; joints of antenna: III, .37; IV, .17; V, .20; VI, including unguis, .17; sensoria as follows: III, none or 1 near distal end; IV, 1 or 2; V, 1 or 2; hind tibiæ with numerous sensoria distributed throughout their length. See figures 11 to 13.

Egg.—1.25 long and .55 in diameter. See figure 14.

Alate Male.—General body color black or blackish; the body more or less covered with white pulverulence, and, on the ventral surface, green when the powder is removed; eyes, antennæ, cornicles, tarsi, distal ends of tibiæ and the greater portion of the femora black; beak reaching the tip of the abdomen; wings with costal margin and stigma blackish, the latter being rather long and broad; stigmal vein heavier than the cross veins of the wings; first and second transverse nerves moderately strong; the cubital vein with its forks very slender and scarcely visible in places; length of body, 2.20; antenna, 1.34; hind tibia, 1.46; wing, 4; antennal joints 3, 4 and 5 with many tuberculate sensoria; III about 30; IV, about 14; V, about 8. The hairs upon the legs and antennæ are rather long, thickly set and very slender. See figures 15 and 16.

This species was first discovered by Mr. Bragg upon Colorado blue spruce in Fort Collins. We have not been able to find it upon other trees. Its rather close ally seems to be *L. palmeræ*, but that species is very common and in no instance

have we found it heavily covered with the white secretion. It appears like a rusty brown or black louse on the twigs, while this one appears like a very light gray or white louse.

Our collection records are as follows:

Fundatrix	Ft. Collins,	Colo.,	April 13, '08, L. C. Bragg,	*Picea parryana*	
	"	"	April 21, '08, C. P. Gillette,	"	"
	"	"	April 28, '08, L. C. Bragg,	"	"
Alate and apterous viviparous females	"	"	April 22, '08, C. P. Gillette,	"	"
	"	"	April 25, '08, C. P. Gillette,	"	"
	"	"	May 14, '08, C. P. Gillette,	"	"
	"	"	May 19, '10, L. C. Bragg,	"	"
	"	"	May 21, '15, L. C. Bragg,	"	"
	"	"	June 12, '14, L. C. Bragg,	"	"
Ovip. ♀	"	"	Oct. 15, '10, L. C. Bragg,	"	"
	Boulder,	"	Oct. 23, '09, L. C. Bragg,	"	"
Male	Ft. Collins,	"	Oct. 15, '10, L. C. Bragg,	"	"

Lachnus tomentosus (De Geer).

Examples of what seems to be this species were taken by the writer from needles of *Pinus radiata*, standing on the campus of the University of California, August 8, 1915, where they were very abundant. The examples taken agree in nearly every respect with the excellent description and figures of this species given by G. Del Guercio in "Contribuzione Alla Conoscenza dei Lacnidi Italiani," 1909, p. 283.

Examples taken on *Pinus scopulorum* in Colorado and listed below, agree so closely with the European form I refrain from giving it even a varietal name.

I give below descriptions and figures made from freshly collected Colorado material. The sexual forms of this louse were found by the writer in very great abundance upon the trees of *Pinus scopulorum* in the City Park of Denver, during the month of October, 1916.

Young Stem Mother.—Specimen taken at Horsetooth Mountain, west of Fort Collins, as early as March 13, 1910. The lice were still hatching and had the habit of arranging themselves in single file, so close that they touched each other, along the needles. When first hatched, the color is dark olive-green with pale yellow legs and antennæ. After a few hours a slight grayish bloom covers the body, the legs and antennæ become considerably darker in color and the cornicles are each in a small dusky circular spot. One or two rows of small dark spots a little inside the lateral margin on either side, extend longitudinally over the abdomen. Beak not attaining tip of abdomen; length of body, 1 millimeter. See figure 17.

Adult Stem Mother.—Entirely cinereous in general color on account of a heavy flocculent secretion covering the body, legs and antennæ. The eyes, ends of the antennæ, cornicles and naked tarsi are deep black; body color, beneath the secretion, dark olive-green, legs dusky with tibiæ black tipped. Length of body 2.10; antennæ, 1; hind tibiæ, 1.30; beak but little surpassing hind coxæ; joints of antennæ: III, longest; IV and V, sub-equal; VI, with very short spur, a little shorter than V; permanent sensoria on joints V and VI only; body antennæ and legs rather sparsely set with long slender hairs. See figures 18 to 20.

Alate Viviparous Female.—Slender and powdery in appearance; length 2; antenna, 1.12; joints of antenna, III, .45; IV, .20; V, .18; VI (with spur), .15; sensoria on joint III usually very faint or appearing to be entirely absent, but as many as 3 weak sensoria found in some examples; hind tibia 1.40; beak barely reaching third coxæ. See figures 21 and 21b.

Apterous Oviparous Female.—Described from specimens taken upon the leaves of *Pinus scopulorum*, Boulder, Colorado, October 23, 1909.

The general color varies from a yellowish brown to a brownish black; the head and terminal joints of the abdomen and the small cornicles black, or blackish; the ventral surface of the abdomen and also the last two segments above, as well as below, covered with pulverulent secretion; antennæ dusky in proximal portion and becoming black towards the distal ends; eyes black; legs black except the basal portion of the middle tibiæ, and in some specimens the anterior tibiæ also; coxæ black; beak reaching the middle pair of coxæ; cornicles quite small, hardly broader than high; length of body, 2.71; length of antennæ, 1.14; joints of antennæ: III, .46; IV, .20; V, .25; VI, .17. The joints are rather slender and set with long slender hairs. Hind tibiæ, 1.75 and considerably swollen in the basal half, where there are numerous circular sensoria. Genital plates black, permanent sensoria only upon joints 5 and 6 of the antennæ. See figures 25 to 28.

Taken depositing eggs in longitudinal rows upon the pine needles. The eggs are covered with the cottony secretion from the bodies of the lice which is rubbed on by means of their hind feet. Figures 23 to 30.

Winged Male.—Body almost black in color, but rather heavily covered with pulverulent secretion, both above and below. The antennæ, legs, costal margin of wings, stigma, stigmatic vein and eyes black. The first and second cross veins are also rather conspicuously black. Second fork of cubital vein, at least in some wings, entirely wanting. Length of body, 2; antenna, 1.57; wing, 3.43; hind tibiæ, 1.60; beak surpassing the hind coxæ; joints of antennæ: III, .60; IV, .29; V, .31; VI, .2. Numerous tuberculate sensoria occur upon joints 3, 4 and 5; upon III, about 28; IV, 14; V, 6; second fork of cubital vein absent on all the wings of the five specimens examined.

The tarsi are very long in this species, the hind tarsus being nearly as long as joint 3 of the antenna. See figure 31.

This species seems very close to *L. pini-radiatae* Davidson.

Collection data as follows:

Fundatrix	Ft. Collins,	Colo.,	April 7, '10,	M. A. Palmer,	*Pinus scopulorum*
	"	"	May 28, '08,	L. C. Bragg,	" "
Alate and apterous viviparous females	Colo. Spr.,	"	June 22, '99,	L. C. Bragg,	" "
	Ft. Collins,	"	June 30, '15,	C. P. Gillette,	" "
	Livermore,	"	July 18, '16,	M. A. Palmer,	" "
Oviparous ♀	Ouray,	"	Sept. 27, '14,	C. P. Gillette,	" "
	Ft. Collins,	"	Oct. 13, '10,	L. C. Bragg,	" "
	Boulder,	"	Oct. 23, '09,	L. C. Bragg,	" "
	Ft. Collins,	"	Nov. 7, '09,	M. A. Palmer,	" "
	"	"	Nov. 25, '09,	M. A. Palmer,	" "
Male	Ouray,	"	Sept. 27, '14,	C. P. Gillette,	" "
	Ft. Collins,	"	Oct. 13, '10,	L. C. Bragg,	" "
	Boulder,	"	Oct. 23, '10,	L. C. Bragg,	" "
	Ft. Collins,	"	Nov. 7, '09,	M. A. Palmer,	" "

***Lachnus ponderosæ** Williams.

Stem Mother.—Described from two specimens taken among many second generation individuals on the bark of the smaller twigs of *Pinus ponderosa*. Specimens taken by Miss Miriam A. Palmer in the foothills west of Ft. Collins.

Ground color of adults golden brown, cornicles black with very large mammiform bases of the same color; powdery above and below; the markings not well defined as the specimens have been rubbed; distal ends of femora and proximal and distal ends of tibiæ black; hind tibiæ with only a small portion near the proximal end pale; beak attaining the tip of the abdomen; anal plates black; length of body 3; width 1.90; hind tibiæ 2. A rather robust species. No figures.

Apterous Female, Second Generation.—Taken April 30, 1910, along with the winged examples described below.

Ground color dark, golden brown; cornicles, tips of antennæ, distal ends of femora and tibiæ, tarsi, transverse patches on joints 1, 2, 7, 8 and 9 of the abdomen; joints 1, 2 and 6 and distal ends of joints 3, 4 and 5 of the antennæ black; lateral margins of the thorax, an irregular median patch on the first three joints of the abdomen and on either lateral one-third of joint 4 of the abdomen powdery white; also small white spots posterior to the cornicles on lateral margins of joints 6, 7 and 8. Length, 2.75; width, 1.50 to 1.75; antenna, 1.17; hind tibiæ, 2; joints of antenna in about the following ratios: 13 : 12 : 61 : 23 : 29 : 21 (with spur). The sensoria are not always easily seen, but in most examples they can be determined as follows: III, 1; IV, 1; V, 2; VI, with terminal or permanent sensoria only. It is not unusual to find two sensoria on joints III and IV and occasionally 3 or 4 may be found on joint III. See figures 32 to 35.

Alate Viviparous Female.—General color of the abdomen the same golden brown as in the stem female; head, thorax, cornicles and anal plate black; antennæ blackish; the basal portions of joints 3, 4 and 5 of the antennæ pale; stigma long, narrow, parallel sided, black and extending nearly one-half the distance from its distal extremity to base of wing; tibiæ with a pale ring near the proximal end; length of body 2.50; wing 4; hind tibiæ, 2.25; joint 3 of antenna as long as 4 and 5 together; 5 distinctly longer than 4; 6 with spur, not quite as long as 4; joint 3 with 4 to 6 large sensoria; joints 4 and 5 with two sensoria each.

Described from many specimens taken at different dates upon the twigs of yellow pine, *P. ponderosa*.

Supplementary description from a dozen fresh specimens just taken from pine twigs brought to the laboratory today, April 13, 1910.

Middle legs entirely black, except for a narrow light ring near the proximal ends of the tibiæ; hind tibiæ entirely black in some examples, others show the pale annulus; entire under surface powdered with white secretion; diagonal white lines more or less distinct upon the mesothorax, and there are four prominent transverse white bands, widest at the middle, upon the dorsum of the abdomen in front of the cornicles;

*Aphididæ of Nebraska, 1910, p. 22.

a spot between the cornicles, and a large transverse band back of the cornicles; sensoria of third joint of antenna four to six in number, and two each upon segments 4 and 5; beak extending nearly to the tip of the abdomen or surpassing it; tibiæ between 1.80 and 2.10. See figures 37 to 42.

Alate Male.—Described from a single specimen in balsam. Length of body, 1.40; antenna, 1; joints of antenna proportioned as follows: III, 26; IV, 15; V, 16; VI (with spur), 13; sensoria rather strongly tuberculate nearly circular and varying greatly in size occurring on all sides of the segments, very numerous on joint III; joint IV with 10 to 12; V, with 5 to 6; VI with 1 besides the terminal group; eyes very prominent; beak long, extending somewhat beyond the tip of the abdomen; hind tibia, 1.25; wing, 3.3;. See figure 40, Plate II.

Taken by Miss M. A. Palmer on *Pinus scopulorum*, Nov. 25, 1909, in the foothills, near Fort Collins.

For the original descriptions, see "The Aphididæ of Nebraska," Williams, in University Studies, Vol. X, No. 2, 1910.

Lachnus pini (Linn), as described by Kaltenbach and Koch, is very close to this species.

We have taken examples of this species, all from *Pinus ponderosa* as follows:

Young Stem Mothers.....	Ft. Collins,	Colo.,	Mar. 3, '10, C. N. Ainsley
Adult Stem Mothers.....	"	"	Mar. 19, '10, M. A. Palmer
Apterous and Alate Viviparous Females....	Boulder,	"	Aug. 7, '98, C. P. Gillette
	Ft. Collins,	"	April 8, '16, L. C. Bragg
	"	"	April 11, '10, M. A. Palmer
	" ft. hills	"	April 13, '09, M. A. Palmer
	"	"	April 23, '11, M. A. Palmer
	"	"	May 13, '10, M. A. Palmer
	Boulder,	"	May 31, '11, L. C. Bragg
	"	"	June 1, '11, L. C. Bragg
	"	"	June 1, '12, L. C. Bragg
	Ft. Collins,	"	June 4, '13, L. C. Bragg
	"	"	June 11, '16, L. C. Bragg
	Walsenburg,	"	June 15, '07, C. P. Gillette
	Boulder,	"	June 18, '09, L. C. Bragg
	Colo. Spr.,	"	June 20, '11, L. C. Bragg
	Boulder,	"	June 24, '13, L. C. Bragg
	Ft. Collins,	"	June 25, '11, M. A. Palmer
	Eldora,	"	June 25, '11, L. C. Bragg
	Boulder,	"	June 28, '06, L. C. Bragg
	Ft. Collins,	"	June 28, '16, L. C. Bragg
	Trinidad,	"	June 30, '10, B. G. D. Bishopp
	La Plata,	"	July 7, '98, C. P. Gillette
	Ft. Collins,	"	July 14, '16, M. A. Palmer
	Livermore,	"	July 18, '16, M. A. Palmer
	Ft. Collins,	"	Aug. 15, '16, M. A. Palmer
Oviparous Females and Males.....	Ft. Collins,	Colo.,	Nov. 23, '10, M. A. Palmer
	"	"	Nov. 25, '09, M. A. Palmer

EXPLANATION OF PLATES.

PLATE X.

Lachnus coloradensis, n. sp. 1, adult fundatrix, × 7; 1a, cauda of fundatrix, × 40; 1b, cauda of fundatrix (side view); 1c, gonopophyses of apterous viviparous, × 70; 2, antenna of fundatrix, × 40; 3, cornicle of fundatrix; 4, young, second generation, one-third grown, × 7; 5 antenna of apterous viviparous, × 40; 6 alate viviparous, second generation, × 7; 7 cornicle of alate viviparous, × 40; 8, terminal three joints of the beak, × 40 (alate); 9, tarsal joints of alate viviparous, × 40; 10, antenna of alate viviparous, × 40; 11, oviparous female, × 7; 12, antenna of oviparous female, × 40; 13, tibia of oviparous female, × 23; 14, eggs laid on spruce needles, × 5; 15, antenna of male, × 40.

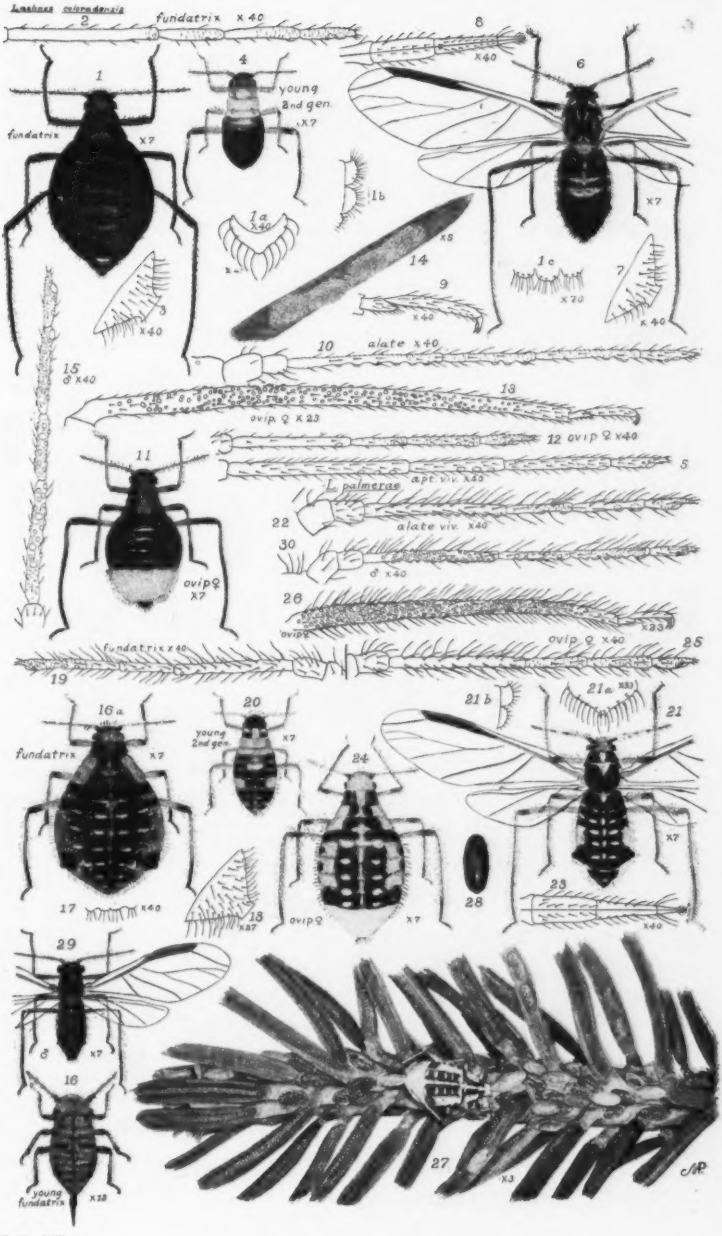
Lachnus palmeræ, n. sp. 16, fundatrix, first instar, × 13; 16a, fundatrix, × 7; 17, gonopophyses of fundatrix, × 40; 18, cornicle of fundatrix, × 27; 19, antenna of fundatrix, × 40; 20, young of second generation, one-half grown, × 7; 21, alate viviparous, second generation, × 7; 21a, cauda of alate viviparous, × 33; 21b, cauda of alate viviparous, side view; 22, antenna of alate viviparous, × 40; 23, terminal three joints of beak of alate viviparous, × 40; 24, oviparous female, × 7; 25, antenna of oviparous, × 40; 26, hind tibia of oviparous, × 23; 27, twig of *Picea engelmanni* with eggs and oviparous female, × 3; 28, egg, × 7; 29, male, × 7; 30, antenna of male, × 40. Original; Miriam A. Palmer, Delineator.

PLATE XI.

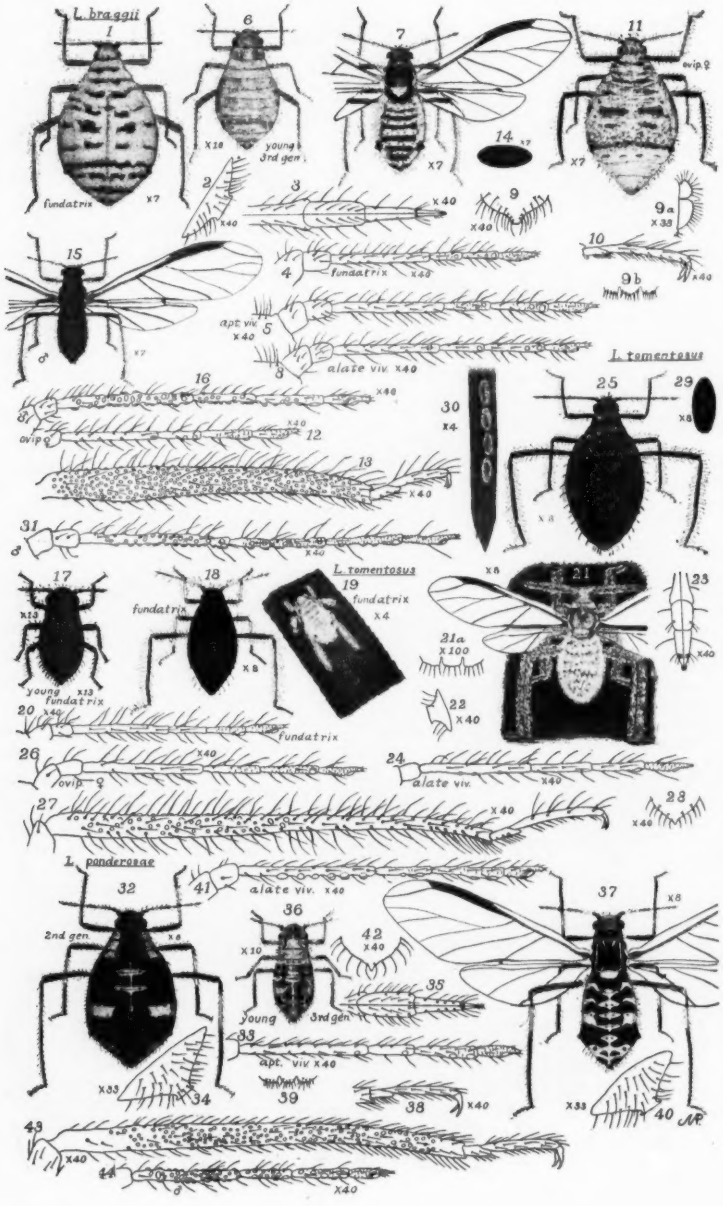
Lachnus braggii, n. sp. 1, fundatrix, × 7; 2, cornicle of fundatrix, × 40; 3, terminal three joints of beak of apterous viviparous, × 40; 4, antenna of fundatrix, × 40; 5, antenna of apterous viviparous, × 40; 6 young of third generation, one-third grown, × 10; 7 alate viviparous, third generation, × 7; 8, antenna of alate viviparous, third generation, × 40; 9, cauda of apterous viviparous, × 40; 9a, cauda of apterous viviparous, side view, × 33; 9b, gonopophyses of apterous viviparous, × 40; 10, tarsal joints of alate viviparous, × 40; 11, oviparous female, × 7; 12, antenna of oviparous female, × 40; 13, tibia of same, × 40; 14, egg of same, × 7; 15, male, × 7; 16, antenna of same, × 40.

Lachnus tomentosus. 17, young fundatrix, × 13; 18, adult fundatrix (with cotton removed), × 8; 19, same with cottony covering on pine needle, × 4; 20, antenna of same, × 40; 21, alate viviparous with cottony covering, × 8; 21a, gonopophyses of same, × 100; 22, cornicle of apterous viviparous, × 40; 23, terminal three joints of beak of oviparous, × 40; 24, alate viviparous antenna, × 40; 25, oviparous female, × 8; 26, antenna of same, × 40; 27, hind tibia of same, × 40; 28, cauda of apterous viviparous, × 40; 29, egg, freshly laid, not yet covered with waxy secretion, × 8; 30, eggs on needle covered with waxy secretion; 31, antenna of male, × 40.

Lachnus ponderosæ Williams. 32, apterous viviparous second generation, × 8; 33, antenna of same, × 40; 34, cornicle of same, × 33; 35, terminal three joints of beak of same, × 40; 36, young of third generation, × 10; 37, alate viviparous, second generation, × 8; 38, tarsus of same, × 40; 39, gonopophyses of same, × 66; 40, cornicle of same, × 33; 41, antenna of same, × 40; 42, cauda of same, × 40; 43, tibia of oviparous, × 40; 44, antenna of male, × 40. Original; Miriam A. Palmer, Delineator.


Lasiopus colpodensis
fundatrix x 40
fundatrix
young 2nd gen.
alate x 40
ovip ♀ x 40
ovip ♀ x 23
apt. viv. x 40
alate viv. x 40
L. palmeras
fundatrix x 40
young 2nd gen.
ovip ♀
young fundatrix
x 3

C. P. Gillette.


L. braggii
fundatrix
young 3rd gen.
apt. viv.
alate viv.
ovip. ♀
L. tomentosus
young fundatrix
fundatrix
alate viv.
L. ponderosae
2nd gen.
young 3rd gen.
apt. viv.

C. P. Gillette.

THE PACIFIC COAST SPECIES OF XYLOCOCCUS. (SCALE INSECTS).

LAURA FLORENCE.

In 1882, at the December meeting of the Société Entomologique de France, M. Victor Signoret (12) read a note from Dr. Franz Löw, calling attention to a recent publication by the Société Zoologique et Botanique de Vienne, of the description of a new Coccid for which he had created a new Genus *Xylococcus*.

The paper was published in 1882, under the title of "*Eine neue Cocciden Art* (*Xylococcus filiferus*)" (10). The insect was first discovered and sent to Dr. Löw in 1878, and he had it under observation from that time until the publication of his paper. He described in detail the first larval stage and the adult female, giving only a brief general description of an indefinite number of intervening stages. The remainder of the paper was occupied with notes on the life history, the position of the insects on the tree, and their method of penetrating into the lower layers of the bark.

There is no further reference to *Xylococcus* to be found until 1890, when in a paper entitled "*How do Coccids Produce Cavities in Plants?*" the author, Mr. W. M. Maskell (11), cited it as an example of a cavity-producing Coccid.

In 1898 a paper was published by H. G. Hubbard and Th. Pergande (6) on a new Coccid found on birch trees. Thus a second species of *Xylococcus* was recorded, the first to be found in America. This, having been found on birch trees in Lake Superior region, was named *Xylococcus betulæ* by Mr. Pergande. The paper was in two parts, the first by Mr. Hubbard was biological, the second by Mr. Pergande structural. In this paper were well pointed out the extremely interesting peculiarities, both structural and physiological, of these curious Coccids.

Both the above-mentioned species were listed by Professor T. D. A. Cockerell (1) in his "*Tables for the Determination of the Genera of Coccidæ.*" He divided the sub-family *Margarodinæ* into two tribes, *Margarodini* and *Xylococcini*. In the latter he placed *Xylococcus* and two allied Genera *Coleostoma* and *Callipappus*.

In the following year, 1900, Mr. E. M. Ehrhorn (5) published a short description of a third *Xylococcus*, which he found on a species of live oak in Stevens Creek Canyon, Santa Clara County, California, and named *Xylococcus quercus*.

In 1902 Professor Cockerell (2) included a brief description of the Genus in "*A Contribution to the Classification of the Coccidæ.*" Reference was made to the work of Löw and of Hubbard and Pergande, and the three known species listed.

In 1905, Mr. S. I. Kuwana (7) presented a description of a fourth species, *Xylococcus matsumuræ*. Three years later a second Californian species was found on the Monterey Cypress trees near Pacific Grove, Monterey County, by Mr. G. A. Coleman (4). He made some short notes on the species, naming it *Xylococcus macrocarpæ*. In the following year, 1909, Professor Cockerell (3) referred *Xylococcus matsumuræ* to a new Genus *Matsucoccus* on the basis of the anal tube and the character of the last joint of the antenna.

Dr. Leonhard Lindinger (9) in his textbook on Scale Insects, published in 1912, gives a brief description of *Xylococcus filiferus* Löw. This has been taken from the original paper.

In 1914, Mr. S. I. Kuwana (8) described a scale insect from oak trees (*Quercus serata*) at Nishigahara, Tokyo, and other places in Japan. He named it *Xylococcus napiformis* n. sp., acknowledging Professor Cockerell's assistance in the determination of the species.

Of the two Californian species, *Xylococcus macrocarpæ* Cole, and *Xylococcus quercus* Ehrh., each stage in the life history of the female and five stages in that of the male are described in detail in this paper. A new species from alder trees is described and I have called it *Xylococcus alni n. sp.* It was collected at Wenatchee, in the State of Washington, by Mr. E. J. Newcomer, of the Bureau of Entomology, who sent it to the Entomological Laboratory of Stanford University.

The distribution of this small group of Coccids presents some interesting features. They have been found on three continents, Europe, America, and Asia, and up to the present time each species has been recorded from one host plant only, *Xylococcus filiferus* Löw, infesting linden trees in Lower Austria, *Xylococcus betulæ Perg.*, infesting birch trees on the shores of Lake Superior, *Xylococcus quercus Ehrh.*, and *Xylococcus napiformis Kuw.*, infesting different species of oak trees, the

former in California and the latter in Japan, *Xylococcus macrocarpæ Cole.* infesting the Monterey Cypress, and *Xylococcus alni n. sp.*, infesting alder trees. From this list it is seen that not only are those insects widely distributed geographically, but they are found on widely separated species of host plant. Nothing is known as to how the trees have become infested, or how the insects penetrate into the lower layers of the bark, where they are found surrounded by secretions of wax.

It is of peculiar interest that the Monterey Cypress, the host of *Xylococcus macrocarpæ Cole.* (Pl. XII, Fig. 1), is indigenous to a single area in California known as Del Monte Forest and extending for a few miles along the Pacific Coast in Monterey County. While collecting my specimens I found the insects on old and young trees alike. The infestation is not evenly distributed in the forest and the most heavily infested trees are easily distinguishable even at a distance by their black colour, due to the growth of a sooty mould fungus in the honey dew exuded by the insects.

Xylococcus quercus Ehrh. (Pl. XII, Fig. 2) I have collected from oak trees (Quercus chrysolepis Liebmann) in Permenente Creek Canyon, Santa Clara County. There is a slight growth of sooty mould fungus on these infested trees also.

These insects infest the trunk and older branches of the trees, and their presence is indicated by numerous filaments of wax protruding from crevices in the bark and bearing drops of honey dew. There is great variety in the length and appearance of these filaments, some being straight, others wavy and almost spiral. This filament is a capillary tube issuing from the posterior end of the body from a chitinous organ called the anal tube, and formed by an extension of the outer walls of circles of chitinous spinnerets, that open into and surround the posterior end of the alimentary canal. Gross dissection shows the insects imbedded between the layers of the bark with their mouth-parts penetrating more deeply. They are surrounded by a homogeneous layer of wax that is given off from pores scattered over the body (Pl. XIII, Fig. 1). The apodous stages of the insect are found in greatest number and in the case of *Xylococcus macrocarpæ Cole.* the characteristic position is in groups varying in number (Pl. XII, Fig. 3). *Xylococcus quercus Ehrh.* (Pl. XIII, Fig. 2) and *Xylococcus alni n. sp.* (Pl. XIII, Fig. 3), are seldom found in groups and their pits are more or less

circular. In the case of the latter the presence of a pit seems to be indicated by a small swelling on the bark. Alongside the insects are found fragments of the wax covering and of the exuviae of previous instars.

The life histories seem to be identical with that of *Xylococcus betulæ Perg.* as previously described. I have not succeeded, however, in finding a stage in the development of the male insect of *macrocarpæ*, or *quercus*, or *alni*, corresponding to Pergande's second stage of *betulæ*. The mouth-parts are very long, and when the larvæ first hatch can be seen coiled inside the insect (Pl. XIII, Fig. 4). The young insects have well developed legs and move about actively before settling down. The male and the female are apparently not distinguishable in the first stage. After the first moult the female loses its legs and antennae and for three successive stages is apodous. Size, difference in number of the wax pores, and structural differences in the stigmatal tubes and anal tube serve to distinguish these stages. After the fourth moult the adult female issues. The insect has now regained the legs and antennæ, but lost the mouth parts (Pl. XIII, Fig. 5). The insect may, without escaping from the exuvia of the fourth stage, rupture the end of the exuvia and present the posterior end of the body at the crevice in the bark for impregnation by the male, or she may escape from the pit and move about freely over the tree. In this case she finally settles under some projection of the bark and spins a cushion of flocculent wax beneath and a covering of powdery wax above her (Pl. XII, Fig. 4). When the eggs are laid the abdomen becomes concave on the lower surface with the lateral margins revolute, so forming a pocket in which the eggs lie buried in wax until they hatch (Pl. XIII, Fig. 6). After egg-laying the female dies, the anterior part of the body shrivelling up.

At the second moult the male insect becomes apodous, closely resembling the female of the third stage. In the fourth stage the legs and antennæ reappear and the mouth-parts and the chitinized anal tube are lost. The insect now emerges and wanders freely over the bark, finally settling under some raised part of the bark. It immediately begins to spin a long slender cylindrical cocoon of flocculent wax and within this the transformation to the pupal stage takes place. The pupæ have well

developed free legs and antennæ (Pl. XIII, Fig. 7), and the adult male (Pl. XIII, Fig. 8) issues from the anterior end, escaping from the cocoon through a small circular aperture. The male is a beautiful insect with two abdominal brushes composed of brittle wax rods produced from groups of pores on the dorsal surface of the sixth and seventh abdominal segments. These brushes are longer than the insect.

The observations on the life history have been made from the trees where the material was collected and from branches brought into the laboratory and kept alive in water. The different stages were collected throughout the year. The males appear to issue during autumn and early winter and females with eggs are found during winter and spring. The larvæ from the eggs of one adult hatch over a considerable period of time. In the laboratory I have had them hatching successively from the same mass of eggs for over six weeks and in the field I found similar conditions.

The biology of these insects was admirably written up by Mr. H. G. Hubbard (6) in 1898, but a few more facts can now be added. In the adopous stages no external traces of the legs remain, but the antennæ are represented by microscopic chitinous discs bearing a few long and a few short hairs. The pigmented eye spots that disappear on boiling the specimens in KOH, are situated near, but not contiguous to these antennal discs. The insects have ten pairs of spiracles, two pairs on the thorax and eight pairs on the abdomen. Those on the abdomen have large simple openings, and within the body form stigmatal tubes with an anterior constriction in which there are one or two rings of pores according to the instar. The thoracic spiracles have no stigmatal tubes. In the active stages their openings are marked by a small group of pores, and in the apodous stages these pores are wanting. In the successive apodous instars an increasing development of the anal tube is visible and this is one of the means of distinguishing them. Mr. Hubbard laid stress on the unusual life history of *Xylococcus betulæ Perg.* and pointed out many peculiarities of structure, showing parallels to them in several species of *Coelostoma Mask.* (*Coelostomidia Ckll.*) and of *Margarodes Guilding.* He suggested that these belonged to a hitherto unrecognized subfamily of the Coccidæ. Since that time *Xylococcus* and five other genera, *Margarodes*, *Coelostoma*, *Callipappus*, *Kuwania*

and *Matsucoccus* have been placed in a new sub-family *Margarodinæ*. The common characters of the sub-family are, in the female, the absence of legs and antennæ in the intermediate stages and of mouth-parts in the adult, in the adult male, the presence of compound eyes. The following table will assist in the identification of the North American species of *Xylococcus*.

I. In first larval stage one median ventral pore.
In apodous stages anal tube without median circles of spinnerets.
macrocarpæ Cole.

II. In first larval stage more than one median ventral pore.
In apodous stages anal tube with median circles of spinnerets.
a. Anal tube with one median circle of spinnerets. Five median ventral pores ..... *betulæ Perg.*
b. Anal tube with two median circles of spinnerets. Median pores varying from 2 to 4 ..... *quercus Ehrh.*
c. Anal tube with three median circles of spinnerets. Median pores varying from 6 to 7 ..... *alni* n. sp.

Xylococcus macrocarpæ Cole.

Eggs.—Length, .55 mm., diameter, .275 mm.; oval, highly polished; colour pale lemon yellow.

Larva, first stage.—Length about .7 mm., diameter about .3 mm. Color on hatching very pale yellow, later becoming tinged with red. Shape oblong-oval, sides sub-parallel narrowing a little posteriorly. Segments all well defined. Eyes black, situated on prominences lateral and posterior to antennæ (Pl. XIV, fig. 1e). Antennæ six-jointed, short, stout; formula 6, 1, 2, 5, (3, 4); joint one stoutest, joints two to five approximately equal in diameter, last joint slender; all joints except three and four bearing hairs that increase in length towards apex; on joint five at base of exterior lateral edge a stout spine; on joint six a ring of four stout spines and a single spine on apex; a very long bristle at apex; a single pore on joint two (Pl. XIV, fig. 1). Legs long and stout; tarsus longer than tibia; a ring of pores, one long hair and one short one on trochanter; digitules on tarsus fine unknobbed hairs, on claw knobbed hairs (Pl. XIV, fig. 2). Rostrum large, situated about middle of body; sucking bristles very long. Anal tube rather short and broad, formed by an extension of the outer walls of a circle of chitinous spinnerets which surround and open into the posterior end of the alimentary canal. Spiracles, two pairs on thorax, eight pairs on abdomen; the former inconspicuous, the latter with well developed stigmatal tubes (Pl. XIV, fig. 3). Body with hairs sparsely scattered over cephalic and thoracic areas, and on dorsal and ventral surfaces of abdomen in transverse rows, one on each segment; a pair of backward directed short lateral spines on each abdominal segment; on ventral surface of segment eight single long lateral bristles; pores of three types; a simple median ventral pore anterior to anal tube; compound lateral pores on each thoracic and first seven abdominal segments dorsally and ventrally; small pores as follows—a pair on cephalic area anterior to prothorax, a pair on the mesothorax, a pair on the metathorax, a pair

on the eighth abdominal segment ventrally; dorsally two pairs on the last two abdominal segments; a single pore adjacent to each abdominal spiracle; in lateral view pores are short chitinous tubes (Pl. XIV, figs. 4a and 4b).

Female, second, third and fourth stages.—Length from about 1.50 mm. to about 4 mm., breadth from about .75 mm. to about 2 mm. Color dark red, posterior end of body brown owing to chitinous nature of last abdominal segments. Shape oblong-oval, bluntly rounded anteriorly; abdominal segments well marked, posterior segments being more compressed than in stage one. Eyes represented by small black pigment spots (disappearing on boiling in KOH), situated near but not contiguous to antennal discs. Antennæ represented by microscopic chitinous discs bearing a few hairs varying in length and number. Legs wanting. Rostrum large, situated about middle of body. Anal tube in second stage with an increased number of spinnerets opening into it anteriorly, in third stage with two anterior circles of spinnerets, and in fourth stage with three anterior circles of spinnerets (Pl. XIV, fig. 5). Two pairs of thoracic and eight pairs of abdominal spiracles; the former inconspicuous, the latter with well developed stigmatal tubes differing from those of first stage as illustrated (Pl. XIV, figs. 3 and 6), and increasing in length in the successive instars; one row of pores in constriction in second and third and two rows in fourth stage. Integument smooth and shining, bearing a few microscopic hairs, and a few lateral abdominal spines. Pores of two types, (Pl. XIV, fig. 7), compound type predominating, distributed irregularly on cephalic and lateral areas and arranged in transverse rows on segments two to seven of abdomen, simple type of pore interspersed among compound type. In successive stages hairs and spines increase in size and pores in number. Pores much more numerous in fourth than in preceding stages, arranged in bands on abdomen, and in all stages increasing in number posteriorly.

Female, fifth stage, adult.—The adult varies in length from 6 mm. to 3 mm. and in breadth from 3 mm. to 1.50 mm.; measurements of largest and smallest specimens found when moulting were respectively 5 mm. x 2.50 mm. and 3 mm. x 1.50 mm., specimens found with eggs 6 mm. x 3 mm. and 4 mm. x 2 mm. Color when living dark olive brown, with an indistinctly spotted appearance due to dark particles in the body fluid; on ventral surface revolute edges yellow; antennæ and legs yellow. Shape oblong-oval, broadest in thoracic region; segments all well defined. Eyes small, black, situated laterad to antennæ. Antennæ stout, nine-jointed; formula 1, 3, 2, (4, 8, 9), 5, (6, 7); joint one longest and stoutest; joint three longer and more slender than two (division between joints two and three not always clearly defined); joints four, five, eight, and nine sub-equal in length and diameter; segments four to eight widening anteriorly where they bear a fringe of hairs; hairs increasing in length towards apex of antenna; last joint flattened at apex, longer at outer side, bearing a few spines as well as hairs; on joint two a small group of pores varying in number, sometimes absent (Pl. XIV, fig. 8). Legs stout and rather short; tibia twice as long as tarsus; trochanter bearing two long hairs and a group of pores varying

in number; digitules on tarsus and on claw fine unknobbed hairs (Pl. XIV fig. 9). Rostrum wanting. Anal tube represented by an infolding of the body wall, not strongly chitinized. Two pairs of spiracles on thorax, eight pairs on abdomen; the former inconspicuous, the latter with well developed stigmatal tubes with two irregular rows of pores in constriction. Integument covered with short stiff hairs stoutest and most numerous anteriorly; a few short spines at posterior end; pores of two types scattered over body (Pl. XIV, fig. 10); on abdomen arranged in indefinite bands; around vaginal opening, which is situated on ventral surface of seventh abdominal segment, they form a dense ring; smaller type of pore predominates.

Male, second stage.—Not found.

Male, third stage.—Length about 2.5 mm., breadth about 1 mm. Similar to stage three of female, but pores on body less numerous. Three posterior abdominal segments chitinised.

Male, fourth stage.—Length about 2.5 mm., breadth about .75 mm. Color dark brownish red; legs light yellow, antennæ dark yellow. Shape oblong with sides sub-parallel; posterior end bluntly rounded; segments all well defined. Eyes large, black; situated laterad to antennæ. Antennæ rather short and stout; formula 1, (2, 3, 9), 8, (4, 5, 7), 6; joint one stoutest, the others gradually diminishing in diameter; joints six to eight broadest anteriorly; nine longer at one side than the other; each joint bearing hairs increasing in length towards apex, terminal joint bearing a few spines as well as hairs; second joint bearing a group of pores varying in number (Pl. XIV, fig. 11). Legs well developed, bearing many stout hairs especially on tibia; tibia almost two and a half times as long as tarsus; trochanter bearing two long hairs and a group of pores varying in number; digitules on tarsus and on claw fine unknobbed hairs (Pl. XIV, fig. 12). Rostrum wanting. Anal tube wanting. Two pairs of spiracles on thorax, eight pairs on abdomen; the former inconspicuous, the latter with well developed stigmatal tubes with one row of pores in constriction. Integument covered with microscopic short, sharp hairs, stouter and more numerous on posterior segments; long, stout hairs and pores of one type (Pl. XIV, fig. 13) thickly scattered over cephalic area; on thorax and abdomen pores arranged in bands segmentally; hairs increasing in number and size posteriorly.

Male, fifth stage.—Cast skin. Length about 1.75 mm., breadth about .7 mm. Color pinkish red; antennæ dusky; legs dark yellow. shape oblong, sides sub-parallel, tapering slightly towards the posterior end; segments all well defined; wing pads reaching end of third abdominal segment. Antennæ long, nine-jointed; formula 9, 2, 3, (1, 8), 6, 5, (4, 7); all joints sub-equal in diameter; without hairs (occasionally a few short hairs present on first joint) (Pl. XIV, fig. 14). Legs long and stout; tarsus about one-third length of tibia with vestigial claw; short hairs present on all joints except tarsus; a group of pores varying in number on trochanter (Pl. XIV, fig. 15). Integument with hairs scattered over cephalic and thoracic areas; on abdomen arranged in

transverse rows corresponding to segments; a few pores of same type as in stage four (Pl. XIV, fig. 13) interspersed among abdominal hairs; a polygonal protuberance at end of body.

Male, sixth stage, adult.—"Length; body 2 mm., width across thorax .8 mm., wings 3 mm. long by 1 mm. broad, expanse about 7 mm.; color of head and thorax dark brown, abdomen yellow, with bands of brown above and below, wings cinereous; veins blackish; only one distinct branch to discoidal vein." (Coleman).

Eyes large, prominent and coarsely facetted. Antennæ ten-jointed, reaching middle of abdomen; joints one and two short and stout; joint three longest; remaining joints diminishing in length and diameter towards apex; all bearing numerous irregularly distributed fine hairs. Two pairs of wings; front pair cinereous with irregularly reticulate surface; discoidal vein with one distinct branch (tending to disappear in mounted specimens); hind wings very small, bearing three stout hooks at apex (Pl. XIV, fig. 16). Legs long, bearing numerous hairs particularly on tibia; tibia nearly twice as long as femur and nearly four times as long as tarsus; tarsus two-jointed, first joint short; digitules fine unknobbed hairs (Pl. XIV, fig. 17). Short fine hairs scattered over integument; on dorsal surface of sixth abdominal segment two groups, each of fifteen pores, on the seventh segment two groups, each of twelve pores (it is from these pores that the abdominal brush issues); style short and conical, with a broad base; sexual organ as long as abdomen and finely annulated (annulations showing under high power of microscope) (Pl. XIV, fig. 18).

Xylococcus quercus Ehrh.

Eggs.—Length .65 mm., diameter .34 mm.; oval, highly polished; color varying from pale orange yellow to light red.

Larva, first stage.—Length varying from .65 mm. to .75 mm., diameter from .35 mm. to .40 mm. Color orange red. Shape broadly oval; segments all well defined. Eyes black, situated on prominences posterior and laterad to antennæ (Pl. XIV, fig. 19e). Antennæ short, stout; six-jointed; formula 6, 1, 5, 2, 4, 3; joint one stoutest; remaining joints approximately equal in diameter; joints three and four without hairs; hairs on joints one, two, five and six increasing in length towards apex; on joint five at base of exterior lateral edge a stout spine; on joint six a ring of four stout spines near the base and a single spine on the apex, a very long bristle at apex; a single pore on joint two (Pl. XIV, fig. 19). Legs long and stout; tarsus longer than tibia; a ring of pores and one long hair on trochanter; a few hairs on tibia and tarsus; digitules on tarsus fine unknobbed hairs, on claw knobbed hairs (Pl. XV, fig. 1). Rostrum large, situated about middle of body; sucking bristles very long. Anal tube protruding from body, being an extension of the outer walls of two groups of chitinous spinnerets that open into the posterior end of the alimentary canal. Two pairs of spiracles on thorax, eight pairs on abdomen; the former inconspicuous; the latter with well developed stigmatal tubes (Pl. XIV, fig. 3). Integument smooth and

shining, after clearing in KOH seen to be covered with microscopic pits, increasing in size posteriorly; hairs scattered over cephalic and thoracic areas, and on dorsal and ventral surfaces of abdomen in transverse rows, one on each segment; a pair of backward directed lateral spines increasing in size posteriorly on each abdominal segment; on ventral surface of segment eight single long lateral bristles; pores of three types—a median ventral row of large pores anterior to anal tube and varying in number from two to four; medium-sized lateral pores on each abdominal segment dorsally and ventrally; small pores as follows: a pair on the mesothorax, a pair on the metathorax, two pairs on each segment of the abdomen ventrally; dorsally a pair on the metathorax, two pairs on the first seven abdominal segments and three pairs on the eighth; in lateral view pores resemble short chitinous tubes (Pl. XIV, figs. 20a and 20b).

Female, second, third and fourth stages.—Length from about 1 mm. to 4 mm., breadth from about 1.75 mm. to about 3 mm. Color deep red, posterior end of body brown owing to chitinous nature of last abdominal segments. Shape sub-spherical; segments not clearly defined; posterior segments more compressed than in stage one. Eyes represented by small black pigment spots (disappearing on boiling in KOH), situated near, but not contiguous to antennal discs. Antennæ represented by microscopic chitinous discs bearing a few hairs varying in length and number. Legs wanting. Rostrum large, situated about middle of body. Anal tube in second stage with an increased number of spinnerets opening into it anteriorly and a sparse median transverse circle of spinnerets, in third stage with three anterior circles of spinnerets and one median transverse circle, in fourth stage with five anterior circles of spinnerets and two median transverse circles (Pl. XIV, fig. 21). Two pairs of thoracic and eight pairs of abdominal spiracles; the former inconspicuous, the latter with well developed stigmatal tubes differing from those of first stage as illustrated (Pl. XIV, figs. 3 and 6), and increasing in length in the successive instars; one row of pores in constriction in second and third stages and two rows in fourth stage. Integument smooth and shining; after clearing in KOH seen to be covered with microscopic pits, increasing in size posteriorly; lateral abdominal spines increasing in size posteriorly; a few hairs scattered over body. Pores of two types (Pl. XV, fig. 2)—large pores scattered on anterior cephalic area; a few small lateral pores on thorax, large and small pores arranged in transverse rows on segments one to seven of abdomen. In the successive stages hairs and spines increase in size and pores in number. Pores much more numerous in fourth than in preceding stages, and in all stages increasing in number posteriorly.

Female, fifth stage, adult.—Length varying from 5.5 mm. to 4 mm., breadth from 4 mm. to 3 mm. Color when living dull brownish red; antennæ and legs brighter. Shape oval, broadest in thoracic region, broadly rounded at posterior end; segments all well defined. Eyes small, black; situated laterad to antennæ. Antennæ long, stout, nine-jointed; formula 1, 9, 2, 3, 6, 4, 7, (5, 8); joints one to four stoutest;

joints five to eight sub-equal; joint nine slender; on joints one and two hairs scattered, on joints three to eight arranged in a fringe at anterior edge and increasing in length towards apex of antenna; terminal joint bearing a ring of four stout spines, two long hairs and a number of shorter hairs; on joint two a group of pores varying in number (Pl. XV, fig. 3). Legs very stout; tibia twice as long as tarsus; trochanter bearing two long, a number of shorter hairs and a group of pores varying in number; digitules on tarsus and on claw fine unknobbed hairs (Pl. XV, fig. 4). Rostrum wanting. Anal tube represented by an infolding of body wall, not strongly chitinised. Two pairs of spiracles on thorax and eight pairs on abdomen; the former inconspicuous, the latter with well developed stigmatal tubes bearing two rows of pores in constriction. Integument covered with short hairs, most numerous on dorsal and lateral areas, and on ventral surface of abdomen arranged in transverse rows segmentally; pores of two types (Pl. XV, fig. 5) thickly scattered over cephalic and thoracic areas, and on abdomen arranged in transverse bands segmentally, the bands on dorsal surface being broader and more dense than those on ventral surface; around vaginal opening pores become more numerous; smaller type of pore predominates.

Male, second stage.—Not found.

Male, third stage.—Similar to stage three of female, but longer and more slender. Pores on body less numerous than on stage three of female; six posterior abdominal segments strongly chitinised.

Male, fourth stage.—Length 2 mm., breadth 1.3 mm. Color deep red; legs and antennæ yellow. Shape oblong, broadest in thoracic region; head and thorax together longer than abdomen; segments all well defined. Eyes small, black, situated laterad to antennæ. Antennæ rather short and stout; nine-jointed; formula 1, 2, 9, 3, 7, (4, 8), 6, 5; joints one to three stoutest; joints four to eight sub-equal; joint nine slender; hairs on each joint increasing in length towards apex, on joints three to eight forming a fringe at anterior extremity; a few spines as well as hairs borne on terminal segment; on joint two a group of pores varying in number (Pl. XV, fig. 6). Legs well developed, bearing many stout hairs; tibia twice as long as tarsus; trochanter with one long hair and a group of pores varying in number; digitules on tarsus and on claw fine unknobbed hairs (Pl. XV, fig. 7). Rostrum wanting. Anal tube wanting. Two pairs of spiracles on thorax and eight pairs on abdomen; the former inconspicuous, the latter with well developed stigmatal tubes with one row of pores in constriction. Integument covered with microscopic short, sharp hairs, stouter and more numerous on posterior segments; long stout hairs and pores of one type (Pl. XV, fig. 8) thickly scattered over cephalic area; on thorax and abdomen these are less numerous and are arranged in bands segmentally; hairs increasing in number and size posteriorly.

Male, fifth stage, pupa.—Cast skin. Length about 2 mm., breadth about 1 mm. Color of abdomen deep red; thorax, legs and antennæ yellow; in dried specimens pigment is broken up, causing a spotted appearance (Pl. XIII, fig. 7). Shape rather broad and short; head and

thorax together longer than abdomen; wing pads broad, reaching beyond hind coxæ. Antennæ long, nine-jointed; formula 1, 3, (4, 5), 9, 6, 2, 7, 8; all joints sub-equal in diameter and distally annulated with white; without hairs (occasionally a few short ones on joint one) (Pl. XV, fig. 9). Legs long and stout, tarsus little more than one-third length of tibia with vestigial claw; short hairs present on all joints except tarsus; trochanter bearing a group of pores varying in number (Pl. XV, fig. 10). Integument with hairs scattered over cephalic and thoracic areas; on abdomen arranged segmentally in transverse rows; a few pores of same type as in stage four (Pl. XV, fig. 8) interspersed among abdominal hairs; a polygonal protuberance at end of body.

Male, sixth stage, adult.—"About 3 mm. long and 1.5 mm. broad, slightly pubescent. Color of abdomen reddish brown. Mesothorax black, with four raised knobs. Front part of head black, eyes very prominent, strongly facetted, black. Legs and antennæ black and very hairy. Ventral surface of abdomen dark brown, segmentation distinct. Mesosternum black, a small black line on prosternum, and an irregular black patch on metasternum. Abdominal brushes with long stout glassy bristles about 6 mm. long. Style short, stout and conical. Antennæ ten-jointed, very hairy, reaching beyond end of abdomen. Joint two shortest, joints three and ten a little longer, and the other joints sub-equal. Each joint with numerous hairs. Wings large, about 3 mm. long and 1 mm. broad, expanse about 7 mm., smoky, slightly pubescent, with the costal space blackish-brown. Halteres resembling small wings with several hooks. Legs long and very hairy. Femur much shorter than tibia. Tibia about four times as long as tarsus. Digitules fine hairs. Claw long and slender and well curved. Digitules short club-shaped hairs." (Ehrhorn).

Xylococcus alni n. sp.

No measurements of this insect were taken, because only dried specimens were at hand.

Eggs.—Color deep lemon yellow.

Larva, first stage.—Color orange red. Shape broadly oval, segments all well defined. Eyes black; situated on prominences lateral and posterior to antennæ (Pl. XV, fig. 11e). Antennæ short, stout, six-jointed; formula 6, 2, 1, (4, 5), 3; joints one and two stoutest; remaining joints approximately equal in diameter; joints three and four without hairs; hairs on joints one, two, five, and six increasing in length towards apex of antenna; on joint five at base of exterior lateral edge a stout spine; on joint six a ring of four stout spines near the base and a single spine on apex; a very long bristle at apex; a single pore on joint two (Pl. XV, fig. 11). Legs long and stout; tarsus longer than tibia; a ring of pores and one long hair on trochanter; a few hairs on tibia and tarsus; digitules on tarsus fine unknobbed hairs, on claw knobbed hairs (Pl. XV, fig. 12). Rostrum large; situated about middle of body; sucking bristles very long. Anal tube large; formed by an extension of the outer walls of a circle of chitinous spinnerets which surround and open

into the posterior end of the alimentary canal. Two pairs of spiracles on thorax and eight pairs on abdomen; the former inconspicuous, the latter with well developed stigmatal tubes (Pl. XIV, fig. 3). Integument smooth, after clearing in KOH seen to be covered with microscopic pits increasing in size posteriorly; hairs sparsely scattered over cephalic and thoracic areas, arranged in transverse rows segmentally on dorsal and ventral surfaces of abdomen; a pair of backward directed lateral spines increasing in size posteriorly on each abdominal segment; on ventral surface of segment eight single lateral long bristles; pores of four types—type I, a median ventral row of large pores anterior to anal tube and varying in number from six to seven; type II, medium-sized lateral pores on each abdominal segment dorsally and ventrally; type III, small pores as follows, a pair on the mesothorax and a pair on the metathorax ventrally, dorsally a pair on the metathorax, a pair on first abdominal segment, and two pairs on the succeeding segments; type IV, very small pores on dorsal surface of segments two to eight of abdomen (Pl. XV, figs. 13a and 13b).

Female, second, third and fourth stages.—Color red, posterior end of body brown, owing to chitinous nature of last abdominal segments. Shape ovoid, broadest in thoracic region, bluntly rounded anteriorly; abdominal segments well marked, posterior segments more compressed than in stage one. Eyes represented by small black pigment spots (disappearing on boiling in KOH), situated near, but not contiguous to antennal discs. Antennæ represented by microscopic chitinous discs bearing a few hairs varying in length and number. Legs wanting. Rostrum large, situated about middle of body. Anal tube in second stage with additional anterior spinnerets and a few median spinnerets, in third stage with an increased number of spinnerets, in fourth stage with two anterior circles of spinnerets and three median transverse circles of spinnerets (Pl. XV, fig. 14). Two pairs of thoracic and eight pairs of abdominal spiracles, the former inconspicuous, the latter with well developed stigmatal tubes, differing from those of first stage as illustrated (Pl. XIV, figs. 3 and 6), and increasing in length in the successive instars, one row of pores in constriction in second and third stages and two irregular rows in fourth stage. Integument smooth, after clearing in KOH seen to be covered with microscopic pits increasing in size posteriorly; a few microscopic hairs on lateral areas; a few small lateral spines posteriorly. Pores of two types (Pl. XV, fig. 15); large pores scattered sparsely on cephalic and thoracic areas; on abdomen large and small pores arranged in transverse rows segmentally; small lateral pores scattered on abdomen. In the successive stages hairs and spines increase in size and pores in number. Pores much more numerous in fourth than in preceding stages and arranged in bands segmentally on abdomen. In all stages pores increase in number posteriorly.

Female, fifth stage, adult.—Color dark red. Shape oblong-oval; segments all well defined. Eyes small, black, laterad to antennæ. Antennæ long and stout; nine-jointed; formula 1, 9, 2, (3, 7), 5, (4, 6, 8); joints one to three stoutest; joints four to eight sub-equal; joint nine

slender; hairs on joints one and two irregular, on joints three to eight distributed in a fringe on widest anterior part of segment; on terminal joint hairs and spines; hairs increasing in length towards apex of antenna; on joint two a group of six pores (Pl. XV, fig. 16). Legs stout and short; tibia more than twice as long as tarsus; trochanter with two long hairs and a group of pores varying in number; hairs on all parts, most numerous on tibia; digitules on tarsus and on claw fine unknobbed hairs (Pl. XV, fig. 17). Rostrum wanting. Anal tube represented by an infolding of the body wall and not strongly chitinised. Two pairs of spiracles on thorax and eight pairs on abdomen; the former inconspicuous, the latter with well developed stigmatal tubes with two rows of pores in constriction. Integument covered with hairs, becoming more numerous posteriorly; pores of two types (Pl. XV, fig. 18) densely scattered over cephalic region and less densely over thorax and abdomen; smaller type of pore predominating.

Male, second stage.—Not found.

Male, third stage.—Similar to stage three of female; pores less numerous than in stage three of female; six posterior abdominal segments strongly chitinised.

The fourth, fifth and six stages of the male of this species have not yet been found.

This study has been made in the Entomological Laboratory of Stanford University, and there, are preserved the type specimens of *Xylococcus alni n. sp.*

The drawings on Plate XIII and figures three and six on Plate XIV are the work of Mr. W. S. Atkinson. The other drawings were made with a camera lucida, and an oil immersion was used in studying the structure of the wax pores.

BIBLIOGRAPHY.

1. **Cockerell, T. D. A.** "Tables for the Determination of Coccidæ." Can. Ent., XXXI, p. 275 (1899).
2. **Cockerell T. D. A.** "A Contribution to the Classification of the Coccidæ." The Entom., XXXV, p. 259 (1902).
3. **Cockerell, T. D. A.** "The Japanese Coccidæ." Can. Ent., XLI, p. 55 (1909).
4. **Coleman, George A.** "Coccidæ of the Coniferæ. Supplement No. 1, Description of two new species." Jn. N. Y. Ent. Soc., XVI, p. 198 (1908).
5. **Ehrhorn, Edw. M.** "New Coccidæ from California." Can. Ent., XXXII, p. 311 (1900).
6. **Hubbard, H. G.,** and **Pergande, Th.** "A new Coccid on Birch." Bull. 18, n. s., Dep. Ag., p. 13 (1898).
7. **Kuwana, S. I.** "Xylococcus matsumuræ n. sp." Insect World, IX, 3, March, (1905).
8. **Kuwana, S. I.** "Coccidæ of Japan." Pomona Journ. Ent. & Zoo., VI, p. 1, (1914).
9. **Lindinger, Leonhard.** "Die Schildläuse (Coccidae)." Hamburg, (1912).
10. **Loew, Franz.** "Eine neue Cocciden-Art (Xylococcus filiferus)." Verh. z. b. Ges., Wien, p. 271, (1882).
11. **Maskell, W. M.** "How do Coccids produce Cavities in Plants?" Ent. Mon. Mag., XXVI, p. 278, (1890).
12. **Signoret, Victor.** "Xylococcus filiferus n. sp." Bull. Soc. Ent. Fr., (6), II, p. CLXXXV (1882).

EXPLANATION OF PLATES.

PLATE XII.

No. 1. *Xylococcus macrocarpæ* Cole. on Monterey Cypress, showing filaments.
No. 2. *Xylococcus quercus* Ehrh. on Quercus chrysolepis, showing filaments.
No. 3. Position of *Xylococcus macrocarpæ* Cole. under bark.
No. 4. *Xylococcus quercus* Ehrh., adult females.

PLATE XIII.

Fig. 1. *Xylococcus quercus* Ehrh., fourth stage of female.
Fig. 2. Position of *Xylococcus quercus* Ehrh., bark removed.
Fig. 3. Pits of *Xylococcus alni* n. sp., insects removed. a, dorsal; b, ventral.
Fig. 4. *Xylococcus quercus* Ehrh., first larval stage.
Fig. 5. *Xylococcus macrocarpæ* Cole., adult female, a dorsal; b, ventral.
Fig. 6. *Xylococcus quercus* Ehrh., adult female showing egg-mass.
Fig. 7. *Xylococcus quercus* Ehrh., pupa of male insect.
Fig. 8. *Xylococcus macrocarpæ* Cole., adult male.

PLATE XIV.

Xylococcus macrocarpæ Cole.

Fig. 1. Antenna of first larval stage; e, eye.
Fig. 2. Leg of first larval stage.
Fig. 3. Abdominal stigmatal tube of first larval stage.
Fig. 4. Posterior segments of abdomen of first larval stage, showing spines, pores, anal tube, and stigmatal tubes; a, dorsal; b, ventral.
Fig. 5. Anal tube of fourth stage of female; a, alimentary canal; b, anterior spinnerets; dd, posterior stigmatal tubes.
Fig. 6. Abdominal stigmatal tube of fourth stage of female, showing two rows of pores in constriction.
Fig. 7. Body pores of apodous stages of female.
Fig. 8. Antenna of adult female.
Fig. 9. Leg of adult female.
Fig. 10. Body pores of adult female.
Fig. 11. Antenna of fourth stage male.
Fig. 12. Leg of fourth stage male.
Fig. 13. Body pore of fourth and fifth stages of male.
Fig. 14. Antenna of pupa of male.
Fig. 15. Leg of pupa of male.
Fig. 16. Hind wing of adult male.
Fig. 17. Leg of adult male.
Fig. 18. Posterior end of body of adult male; a1, groups of pores; a2, pore enlarged; b, sexual organ.

Xylococcus quercus Ehrh.

Fig. 19. Antenna of first larval stage; e, eye.
Fig. 20. Posterior segments of abdomen of first larval stage, showing spines, pores, anal tube, and stigmatal tubes; a, dorsal; b, ventral.
Fig. 21. Anal tube of fourth stage of female; a, alimentary canal; b, anterior spinnerets; c, median spinnerets; dd, posterior stigmatal tubes.

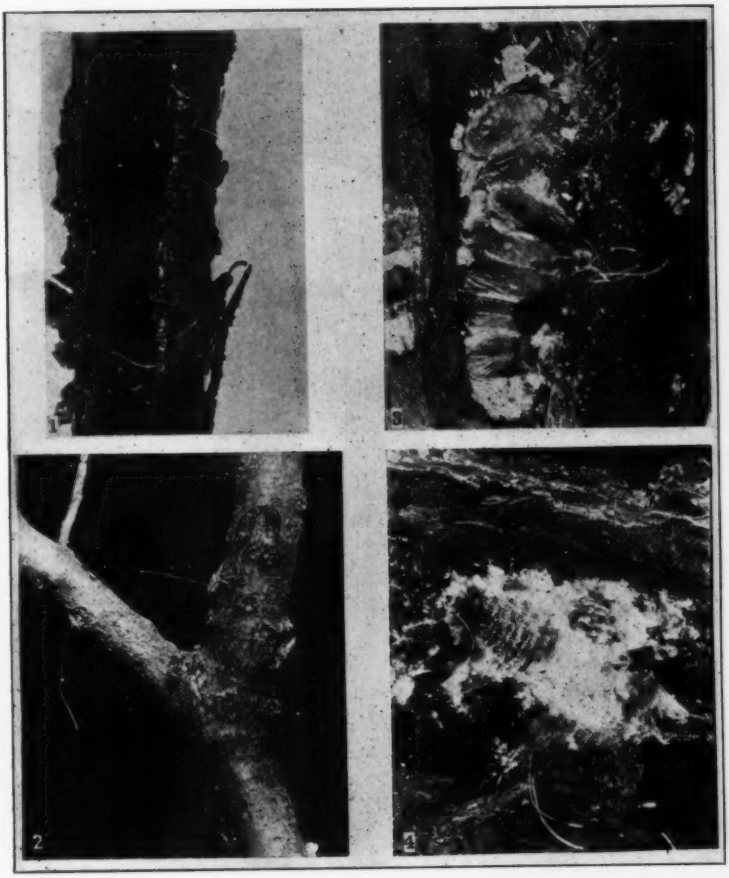
PLATE XV.

Xylococcus quercus Ehrh.

Fig. 1. Leg of first larval stage.
Fig. 2. Body pores of apodous stages of female.
Fig. 3. Antenna of adult female.
Fig. 4. Leg of adult female.
Fig. 5. Body pores of adult female.
Fig. 6. Antenna of fourth stage male.
Fig. 7. Leg of fourth stage male.
Fig. 8. Body pore of fourth and fifth stages of male.
Fig. 9. Antenna of pupa of male.
Fig. 10. Leg of pupa of male.

Xylococcus alni n. sp.

Fig. 11. Antenna of first larval stage; e, eye.
Fig. 12. Leg of first larval stage.
Fig. 13. Posterior segments of abdomen of first larval stage, showing spines, pores, anal tube, and stigmatal tubes; a dorsal; b, ventral.
Fig. 14. Anal tube of fourth stage of female; a, alimentary canal; b, anterior spinnerets; c, median spinnerets; dd, posterior stigmatal tubes.
Fig. 15. Body pores of apodous stages of female.
Fig. 16. Antenna of adult female.
Fig. 17. Leg of adult female.
Fig. 18. Body pores of adult female.



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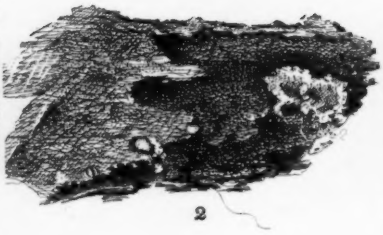
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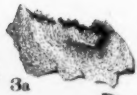
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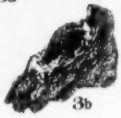
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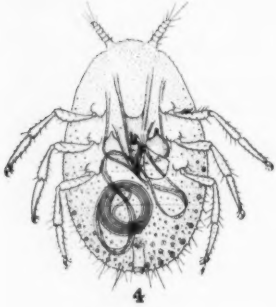
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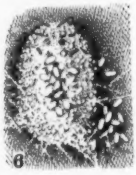
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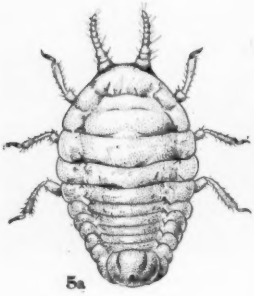
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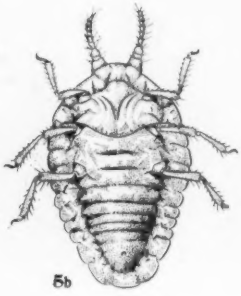
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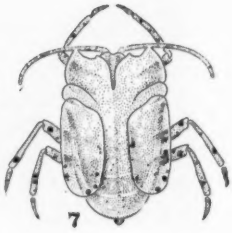
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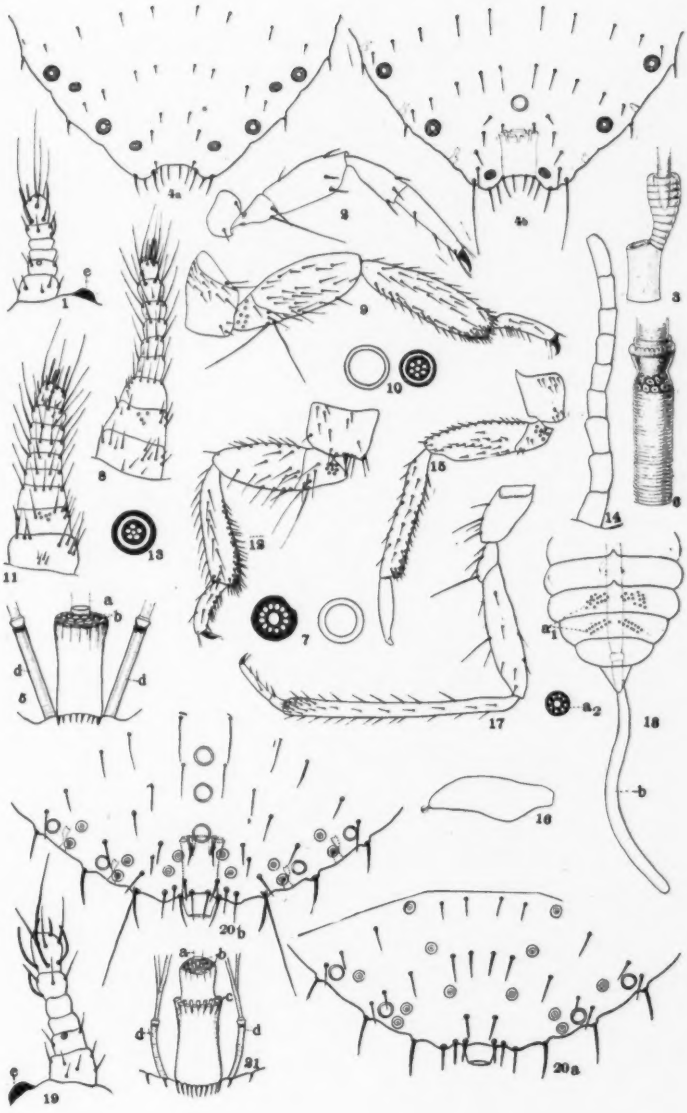

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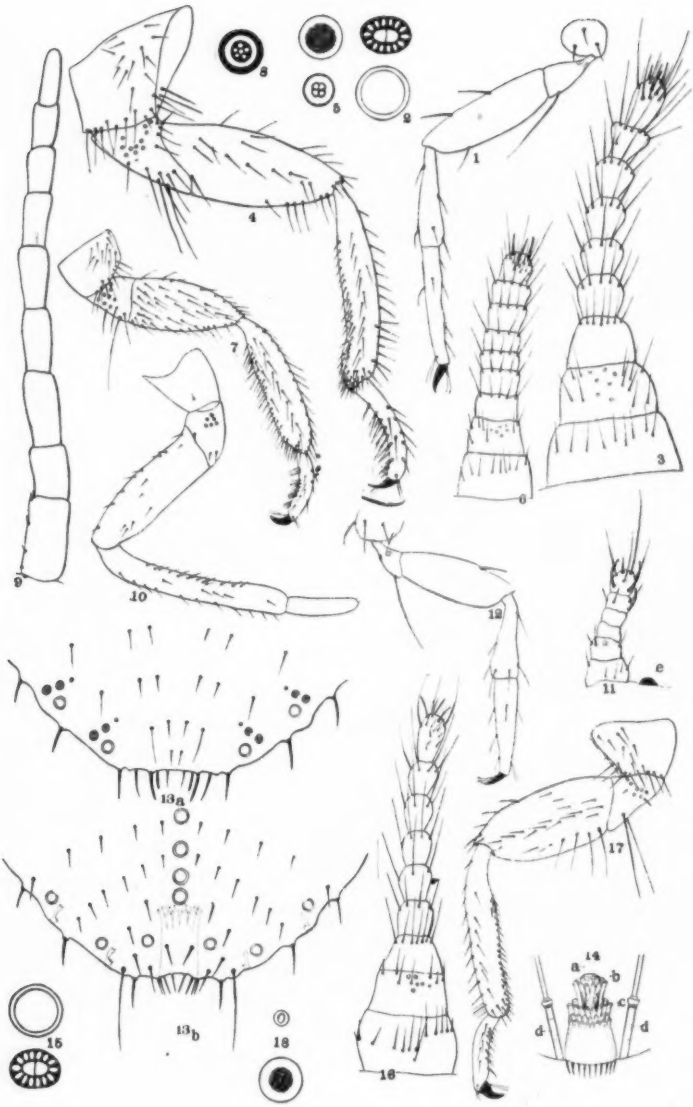

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SIX NEW SPECIES OF MALLOPHAGA FROM NORTH AMERICAN MAMMALS.

By E. A. McGregor, Bureau of Entomology.

Trichodectes kingi n. sp.

Two females (Bishopp No. 2464) from weasel, *Putorius* sp., (Florence, Mont., June 16, 1910, coll. W. V. King), female and immature specimens (Bishopp No. 3181) from weasel (Florence, Mont., April 21, 1914, coll. H. P. Wood), and five females (Bishopp No. 3219) from weasel (Florence, Mont., April 18, 1914, coll. H. P. Wood).

This species is nearest *T. retusus N.* and *T. minutus* Paine. The former is from *Mustela vulgaris* and *M. erminea*, and the latter from *Putorius noveboracensis*. It differs materially from *T. retusus* in the entire absence of spines on the dorsal portion of the abdominal segments. It differs from *T. minutus* in the more elongate head, in the absence of dorsal abdominal spines, and in the rather distinct transverse, abdominal blotches.

Description of Female.—Total length, 1.139 mm.; length of head, .305 mm.; length of prothorax, .08 mm.; length of metathorax, .059 mm.; length of abdomen, .694 mm.; width of head across temples, .32 mm.; width of prothorax, .29 mm.; width of metathorax, .36 mm.; width of abdomen, .48 mm.

Head slightly wider than long, rather abruptly narrowed anteriorly, with a very distinct median emargination, and produced into a prominent trabecula-like process just before each antenna. Antennal sinuses of considerable longitudinal span, but very shallow. Ocular projections not prominent. Temple margins diverge slightly posteriorly and meet the occipital margin without an angle. Occipital margin of one even, rotundate curve from temple to temple. Antennal bands not decidedly distinct, separated from each other anteriorly by a rather wide, clear area, continued faintly across the antennal bases to the ocular blotch which is very distinct. A small triangular, posterior-pointing flap projects dorsally at the hind end of the distinct portion of the antennal bands. Occipital bands broad and distinct at their bases, continued narrower and fainter to the ocular blotches. Underlying bands are visible, extending from the bases of the occipital bands to the mandibles. Four short hairs occur on each anterior margin between the median emargination and the trabeculæ, one weak hair arises from the eye and one immediately behind this, two long hairs at the temporal prominence, and three weak hairs between the latter and the prothorax. Antennæ of average size, about reaching the posterior margin of the head; the three segments of about equal length.

Thorax about three times as broad as long. Prothorax lenticular in outline, with the posterior margin very slightly convex. Four weak spines distributed along the lateral margin. Metathorax at first abruptly diverging, than as abruptly converging, with a wide, angulated emargination medially. A very short spine at each posterior lateral angle, a long hair just behind this, and a similar hair midway on the converging margins. Legs normal.

Abdomen subquadrate in outline, widest on the third segment. Segments 1 to 6 with rather well defined plates at the lateral borders. Each of the twelve plates with a hair near the posterior angle. First segment devoid of spines. Second segment with a spine at each lateral border. Third to fifth segments each with a lateral group of three spines. Sixth and seventh segments each with a lateral group of four spines. Eighth segment with a transverse row of six spines, and with six spines on the posterior margin—three on either side of the center. Segment eight slightly, and segment nine deeply emarginate medially. Segments two to seven each with a spiracle at the lateral margins. Transverse spines lacking on segments one to seven, inclusive.

Trichodectes floridanus n. sp.

Four females (McGregor, No. 9878) from dog, Monticello, Fla., November 26, 1913, coll. H. B. Scammell.

This species is nearest *T. latus* N., also of the dog, but is clearly distinct through the nature of the antennæ, the female appendages, the shape and markings of head, the shape of the thorax, and in the presence of the prominent spiracles on the prothorax.

Description of Female.—Total length, 1.5 mm.; length of head, .37 mm.; length of prothorax, .135 mm.; length of metathorax, .083 mm.; length of abdomen, .915 mm.; width of head between eyes, .551 mm.; width of prothorax, .405 mm.; width of metathorax, .488 mm.; width of abdomen, .811 mm.

Head just half again as wide as long, with a wide, shallow emargination anteriorly, and with the usual trabecula-like process just before each antenna. Antennal sinuses distinct, but not deep. Ocular projections distinct, but not prominent. Temporal margins commence to converge immediately behind the eyes, and meet the occipital margin with an obtuse curvature. Occipital margin rather concave for nearly the entire width of the prothorax. Antennal bands scarcely discernible, reduced to faint, linear spots at the posterior ends of the clypeal margins which are the darkest portions of the head. A crescent-shaped spot of about the color of the antennal bands occurs just inside each of the antennal sinuses. Occipital bands entirely lacking. Five short hairs occur on each of the clypeal margins, a similar hair occurs at the base of each trabecula just over which a longer hair arises, one short hair arises from each eye and one immediately behind this, two longish hairs near the temporal angle, three weak spines on each side

near the junction of the head and prothorax, and a long hair just mediad of these. Antennæ joints of nearly equal thickness, but with the third nearly equal in length to the other two.

Thorax about two and one-third times as wide as long. Prothorax rather lenticular in outline, with the median portion of the hind margin decidedly convex. A weak spine on each side at the outer ends of the anterior margin, and a stronger hair on each lateral margin just over the conspicuous, protruding spiracles, and a long hair on each side near the hind margin midway between the median line and the lateral border. Metathorax with rather abruptly converging sides, the conspicuously concave posterior margin forming nearly right angles with the lateral borders. A very short spine at each anterior lateral angle, three long hairs arising behind these so that bases form curves bending backward and inward from the spines at the angles. About eight hairs arise along the median part of the concave margin. Legs conventional.

Abdomen widely oval in outline, broadest on the second and third segments. First segment with a series of eight or nine hairs at the anterior margin medially, and with four or five spines along the lateral margin. Segments one to six, inclusive, with a stiff hair near each posterior lateral angle, and segments one to seven, inclusive, each with a transverse series of from sixteen to twenty four dorsal spines. Segments two to seven, inclusive, with a rather distinct spiracle on each lateral margin. Terminal segment rather deeply emarginate medially, with a central cluster of four dorsal spines, a transverse series of four weak spines, and a longer spine at the middle of each lateral border.

Trichodectes thomomyus n. sp.

Two females and one male (Bishopp No. 2604) from *Thomomys* sp., Jefferson, Colo., May 7, 1912, C. Birdseye, coll., and one immature specimen (Bishopp No. 2606) from the same host and locality, May 12, 1912.

This species is most nearly allied with *T. geomydis* Osb., from which it is easily distinguished by the absence of a process on the second joint of the female antennæ which are inserted before the middle of head; the straight, truncate hind margin of head; and by the shape of the metathorax.

Description of Female.—Total length, 1.111 mm.; length of head, .314 mm.; length of prothorax, .0837 mm.; length of metathorax, .0418 mm.; length of abdomen, .68 mm.; width of head across temples, .398 mm.; width of prothorax, .298 mm.; width of metathorax, .387 mm.; width of abdomen, .586 mm.

Head nearly a third again as wide as long, with a distinct, somewhat V-shaped median emargination, produced into stout, trabecula-like processes just before each antenna. Antennal sinuses only fairly deep, but of considerable longitudinal span. Ocular projections lacking. Temple margins at first are nearly parallel, but at their midpoints bend abruptly inward and meet the occipital margin at an obtuse angle.

Occipital margin almost a straight line. Antennal bands distinct, of moderate width, separated from each other at the front of head by the rather wide clear area coincident with the ample emargination at the borders of which they bend sharply backward for a short distance. Antennal bands continue clearly across the bases of the antennæ to the very distinct ocular blotches at which points they are continuous with the clearly defined occipital bands. Faint underlying bands extend from the bases of the occipital bands convergingly toward the mandibles. A broad band borders the occiput between the occipital bands. Five short hairs on each margin between the anterior emargination and trabeculæ, two on each side at the anterior border of the antennal sinus, one just within the posterior angle of antennal sinus, three longer hairs along the posterior half of temples, and eight weak spines on the dorsal surface of head. Antennæ rather stout, of three subequal joints, none of which possess a projecting process.

Thorax about three times as broad as long. Prothorax very short as compared to breadth. Sides divergent to posterior margin, which is somewhat 3-faceted. A strong spine at the posterior lateral angles and one near each end of the middle facet. Metathorax shorter than the prothorax and broader, the lateral border projecting on each side as a sharply rounding prominence, and with a wide, deep posterior median emargination. Three hairs set closely near the lateralmost portions and a transverse row of four stronger spines. Legs relatively short and stout.

Abdomen oval in outline, one-fifth longer than wide, widest on second segment. Segments one to three with pointed lateral plates which are directed inward and backward. Each lateral plate with a series of about five longish spines. First segment with two spines within the thoracic emargination, four or five short spines along the lateral margin, and a transverse series of about eighteen spines. Second segment with a series on each side—just inside the lateral plates—of about four weak spines, and a transverse row of about eighteen longer spines. Segment three with a transverse row of about seventeen long spines. Segment four with a transverse row of about thirteen spines, and on each side a series of about five spines. Segment five with about twenty-one spines in a transverse series. Segment six with a transverse series of about thirty spines. Seventh segment with three long spines at each posterior lateral angle, and a series of four placed medially. Segment eight with a transverse series of six long spines. Terminal segment subconical, sharply emarginate, and with four slender hairs subterminally. Seventh segment with a pair of chitinized, lateral female appendages.

Head of male a trifle wider relatively than that of female; anterior emargination deeper and more acute; antennal sinuses deeper; anterior angle of temple much more rounded; occipital margin somewhat concave.

Trichodectes monticolus n. sp.

Six females and two males (Bishopp No. 6837) from skunk, Topaz, Calif., September 15, 1916, coll. J. L. Webb.

This species, from the California Sierras, is nearest *T. mephitidis* Osb. from which it differs as follows: FEMALE.—A fairly well-developed angle at point of junction of temples with occiput; hairs on front of head; lateral borders of metathorax strongly converging, posterior border widely and deeply excavated. MALE.—Frontal emargination represented merely by a transparent spot; antennæ with basal joint not greatly longer than third, a pair of angulated processes on the basal and second joints at the dividing suture which are opposed to one another, terminal joint with a blunt spur on posterior margin near base; antennal sinuses more deeply excavated; temporal lobes more prominent.

Description of Female.—Total length, 1.07 mm.; length of head, .313 mm.; length of prothorax, .062 mm.; length of metathorax, .038 mm; length of abdomen, .665 mm.; width of head across temples, .380 mm.; width of prothorax, .280 mm.; width of metathorax, .313 mm.; width of abdomen, .541 mm.

Head about one-fifth wider than long, rather generally rounded anteriorly, with a small but distinct median emargination, and with the usual trabecula-like flaps before each antenna. Antennal sinuses rather shallow. Ocular projections prominent. Temporal margins parallel one another for a short distance behind eyes, but soon converge to meet the occipital margin at an obtuse angle. Starting at these angles the occipital margin on either side first curves inward and then bends back again to form a strong median convexity. Antennal bands rather broad and very distinct, anteriorly bending abruptly at an acute angle to form expanded, backward-pointing bars which inclose a clear area behind the emargination, and continued distinctly across the antennal bases to the well-defined ocular blotch. A semicircular, hyaline flap projects backward, dorsally, just within that portion of the antennal bands lying abreast of the trabeculæ. Occipital bands at their bases broad and distinct, continued narrower and fainter about half way to the ocular blotches. Underlying bands are visible extending from the bases of the occipital bands to the mandibles. Five weak hairs occur on each anterior margin between the frontal emargination and the trabeculæ, one weak hair arises from the rear of the eye, five short hairs occur along the temporal margin, and one long hair arises on each side at the temporal-occipital angle. Antennæ of average size, the last joint the longest, but with no marked difference between them.

Thorax three and one-third times as wide as long. Prothorax sub-rectangular, with posterior margin slightly convex. A weak spine

at the posterior lateral angle, another just within the anterior angle, and a long spine arises on each side midway to the center. Metathorax at first abruptly diverging for a very short distance, and then as abruptly converging with a concave-bordered excavation medially. A short spine at the lateralmost points, three long spines along the converging sides, and eight longish spines along the border of the emargination. Legs normal.

Abdomen oval in outline, widest on the third and fourth segments. First segment with six short spines along each lateral margin, a series of eight across that part within the metathoracic excavation, and about twenty-two in a transverse series along the hind margin. Segments two to seven, inclusive, with transverse rows of spines as follows: Segment two, twenty-six spines; segment three, twenty-seven spines; segment four, twenty-two spines; segment five, eighteen spines; segment six, twenty spines (of very uneven length); segment seven, fourteen spines. Segment eight with a long hair within each of the chitinized appendages (arising from the seventh segment), and two weak hairs near the posterior tip.

Male.—Head one-third again as wide as long; antennal sinuses much deeper than those of female, and are nearly filled by the ample trabecula-like processes; temples narrower but more prominent; anterior median emargination represented merely by a transparent V-shaped spot. Antennæ with basal joint swollen; a pair of pincer-like processes on the basal and second joints opposed to one another across the dividing suture; last joint with an obtuse-angled spur on inner margin near base.

Trichodectes scleritus n. sp.

Numerous females and immature individuals (McGregor No. 4321) from gopher, Florida.

This species is somewhat intermediate between *T. geomydis* Osb. and *T.* californicus Chapm., probably nearest the former as figured by Kellogg and Ferris. Very distinct through the following characters: Hooked trabeculæ; presence of posterior prominence on second and third antennal joints; conspicuous lateral sclerites on first to fifth abdominal segments, inclusive.

Description of Female.—Total length, 1.04 mm.; length of head, .284 mm.; length of prothorax, .092 mm.; length of metathorax, .042 mm; length of abdomen, .625 mm.; width of head across temples, .412 mm.; width of prothorax, .298 mm.; width of metathorax, .341 mm.; width of abdomen, .575 mm.

Head almost half again as wide as long, generally rounded anteriorly with a conspicuous, semicircular median emargination, and produced into a hooked trabecula-like appendage at the base of the antennæ. Antennal sinuses moderately deep and wide. Ocular projections not very prominent. Temple margins diverge little, and soon curve convergingly to meet the occipital margin, forming with it rather

prominent lobes. Occiput very slightly convex. Antennal bands not very distinct, separated from one another anteriorly by the ample emargination at the sides of which they bend abruptly backward as darker bars; continued faintly across the antennal bases to the fairly distinct ocular blotch. Occipital bands barely discernible, paling to invisibility half way to the ocular blotches. Underlying bands are seen extending from the bases of the occipital bands to the base of mandibles at which point occurs on each side a small dark blotch. Three hairs arise from the front margin on each side of the median emargination, two arise midway to the trabeculæ, three just before the antennæ, two on each side from clear areas just within the clypeal margin, a hair arises from the eye, four occur along the temple, one at each lateral end of the occipital margin, and six weak hairs occur near the central portion of the dorsal aspect. Antennæ of generous dimensions, the second and third joints with posterior prominences.

Thorax two and two-thirds as broad as long. Prothorax trapezoidal, the sides diverging posteriorly, with slightly convex posterior margin. A short spine at the posterior lateral angle, and four weak hairs near the middle. Metathorax with conspicuous lateral extensions, then abruptly converging to the evenly concave posterior margin. Two shortish spines on the lateral wings, a long hair just behind these, and a transverse series of six long hairs. Legs about as usual.

Abdomen oval in outline, widest on the third segment. Segments one to five inclusive with conspicuous lateral plates. Plates I with three marginal spines and one dorsal spine; plates II with two marginal and three dorsal spines; plates III with three marginal and two dorsal spines; plates IV with three marginal and one dorsal spine; plates V with three long submarginal hairs. Segment one with two median spines just behind the thoracic border, and with a transverse series of about eleven spines. Segment two with a transverse series of about fourteen spines. Segment three with a transverse series of about eighteen spines. Segment four with a transverse series of about seventeen spines. Segment five with about fifteen spines in a transverse series. Segment six with a transverse row of about seventeen spines. Segment seven with four long hairs near the posterior lateral angle and two near the middle. Segment eight with a lateral series at each side of three spines each just within the female appendages, and with six weaker ones near the notched tip.

Trichodectes odocoilei n. sp.

Three females (Bishopp No. 2468) from White-tailed deer (*Odocoileus virginianus macrourus*), Lolo Hot Springs, Mont., June 23, 1910, coll. W. V. King.

This species agrees fairly well with *T. tibialis* Piag. as figured by Morse and by Osborn, but it is very distinct from the original description and figure of Piaget, especially in the following characters: Point of insertion of antennæ; front of

head not with "multitude" of hairs as Piaget states for tibialis; shape of thorax (especially metathorax); general outline of abdomen; character of abdominal blotches; the distribution of dorsal spines; and in the markings on the eighth and ninth abdominal segments.

Description of Female.—Total length, 1.72 mm.; length of head, .492 mm.; length of prothorax, .102 mm.; length of metathorax, .102 mm.; length of abdomen, 1.025 mm.; width of head across temples, .471 mm.; width of prothorax, .369 mm.; width of metathorax, .430 mm.; width of abdomen, .533 mm.

Head slightly longer than wide, unusually elongate, truncate anteriorly by a wide, shallow emargination, and produced into the trabecula points just before the antennæ. Antennal sinuses shallow. Ocular projections quite noticeable. Temple margins at first parallel one another, then curve abruptly inward to the occipital margin with which they do not form angles. The occiput is nearly straight, but slight emarginations occur just mediad of the bases of the occipital bands. Antennal bands broad and distinct, bending abruptly inward just before the bases of the antennæ and not continued to the inconspicuous ocular blotch, bent directly backward at the lateral angles of the anterior emargination, forming bars which reach to the mandible bases. A backward-pointing triangular plate which is narrowly cleft to the apex fills the space between the truncated front and the mandibles. Occipital bands narrow and faint, paling before reaching the antennal bands. Between the bases of the occipital bands are a pair of sharply recurved blotches. Two short hairs occur on the truncate front, two at each of the frontal angles, seven along the outer margin of the antennal bands, five on the temples, eight in a curving row in front of the mandibles, and a dozen disposed dorsally on the posterior half of the head. Antennæ long, slender, the second joint the longest, the third slightly curving.

Thorax twice as broad as long. Prothorax roughly rectangular, with posterior margin slightly convex with a weak median concavity. A conspicuous spiracle at each lateral border. A weak spine just before each spiracle, a similar one at each posterior lateral angle, and a pair near the middle of the segment. Metathorax with sides first diverging and ten parallel, posterior margin running slightly forward to form an obtuse-angled emargination. A short spine at each posterior lateral angle, and ten along the posterior border of which four are long and six short. Legs conventional.

Abdomen with sides sub-parallel, widest on third segment. Segments two to seven, inclusive, with conspicuous lateral spiracles. Segments one to seven, inclusive, with dusky, transparent blotches which are separated from the lateral bands of similar color by narrow, clear spaces. Segment eight with a pair of smoky, elliptical blotches. Segments one to six, inclusive, with a short hair in front of the posterior lateral angles; segment seven with a longer hair at the angles. Seg-

ments one to seven, inclusive, each with a transverse series of short spines as follows: Segment one, seventeen spines; segment two, twenty-one spines; segment three, seventeen spines; segment four, sixteen spines; segment five, sixteen spines; segment six, eighteen spines (two at each side longer); segment seven, ten spines (one at each side longer). The eighth segment with a transverse series of six spines, the outer two of which are long, and with four arising at the tip which is sharply notched. All of the abdominal spines arising from clear pustulations.

EXPLANATION OF PLATES.

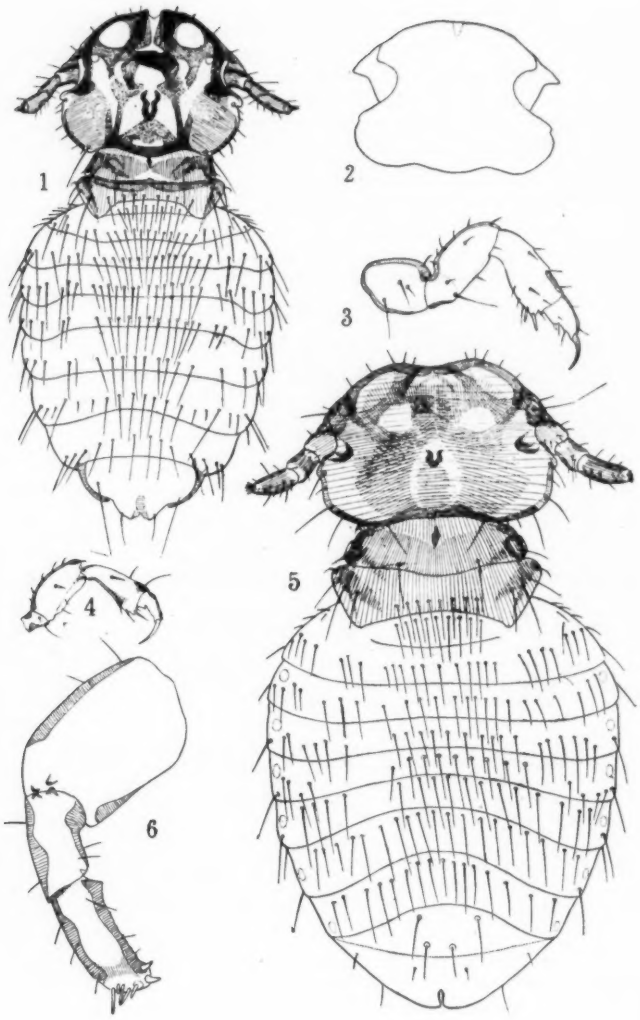
PLATE XVI.

Fig. 1. Female of *Trichodectes monticolus* n. sp.
Fig. 2. Head of male of *Trichodectes monticolus* n. sp.
Fig. 3. Left leg III of female of *Trichodectes floridanus* n. sp. (viewed ventrally).
Fig. 4. Left leg III of female of *Trichodectes monticolus* n. sp. (viewed ventrally).
Fig. 5. Female of *Trichodectes floridanus* n. sp.
Fig. 6. Antenna of male of *Trichodectes monticolus* n. sp.

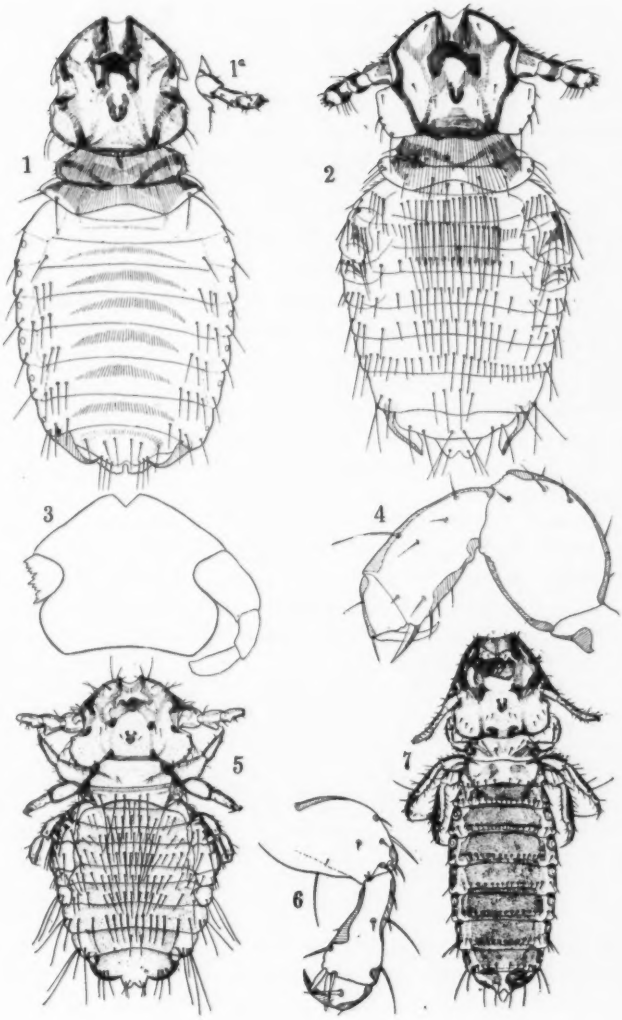
PLATE XVII.

Fig. 1. Female of *Trichodectes kingi* n. sp.
Fig. 1a. Antenna of female of *Trichodectes kingi* n. sp.
Fig. 2. Female of *Trichodectes thomomyus* n. sp.
Fig. 3. Head of male of *Trichodectes thomomyus* n. sp.
Fig. 4. Right leg III of female of *Trichodectes thomomyus* n. sp. (viewed ventrally).
Fig. 5. Female of *Trichodectes scleritus* n. sp.
Fig. 6. Right leg II of female of *Trichodectes kingi* n. sp.
Fig. 7. Female of *Trichodectes odocoileis* n. sp.

The drawings have been made through the employment of the camera lucida with little attempt to restore symmetry.



E. A. McGregor.



E. A. McGregor.

HIBERNATION: A PERIODICAL PHENOMENON.

By J. P. Baumberger, Bussey Institution.

Hibernation may be defined as the quiescent condition characteristic of many organisms during winter. A number of investigators have studied the phenomenon for the plant and animal kingdoms and have assembled a large mass of facts as to the physiological conditions and the habits of hibernating organisms. The studies have also included the causes of this quiescence and a number of hypotheses have been proposed.

Confining ourselves to insects the most commonly proposed hypothesis is that low temperature or low mean temperature is conducive to hibernation. In a previous paper[1] the author analysed an amount of temperature data with reference to the date of hibernation of the Codling Moth and showed that in the cases studied a marked lowering of average temperature or a very low temperature did not immediately precede the date of hibernation. The author has during the past two years carried on some experiments with the banana fly (*Drosophila melanogaster* Meigen) with the object of determining whether or not a hibernating period could be established by the stimulus of low temperatures. In this experiment eggs, larvæ, pupæ and adults of the same parents were kept in the ice box and in the greenhouse.

TABLE I.

Pupal Period.

Number Pupæ	Number Days in Ice Box	Temp.	Number Days in Greenhouse	Temp.
370	10	41-43° F.	8.43	58-86° F.
340	0	41-43° F.	9.09	58-86° F.

The proceedure was as follows: pupæ were placed in the ice box for ten days and then removed to the green house. At the date of removal pupæ which had just formed were also placed in the greenhouse. The periods of time that elapsed before emergence of the adults was then compared. The results show

that a persistent quiescent condition was in no case brought about by this treatment. Larvæ and adults after twenty days in ice box were immediately activated by high temperature.

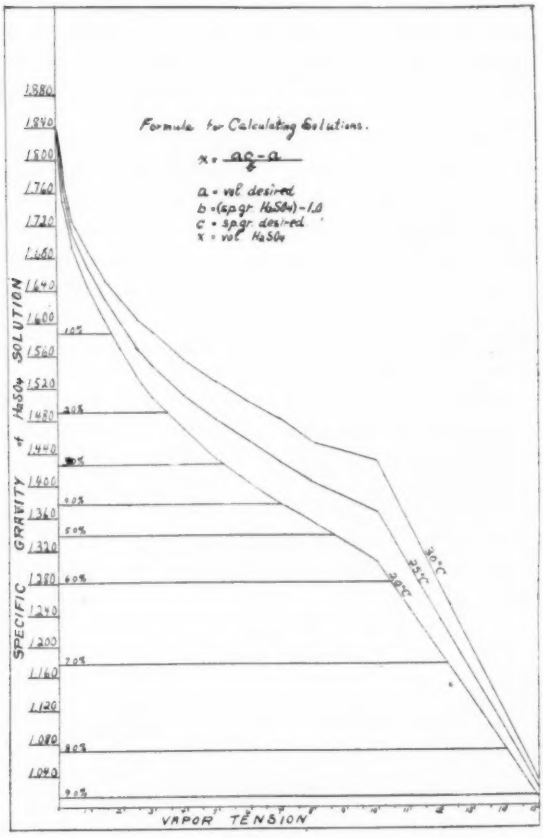


FIGURE 1

In order to avoid confusion it would be well to state, at this point, that in general hibernation in insects is characterized by quiescence which persists for sometime after the temperature has risen or continues through periods of high temperature. In many cases the phenomenon manifests itself before the temper-

ature falls. In this case the condition can be recognized by a pause in feeding and in growth. The Codling Moth has already been cited as an example of this peculiarity. It might also be said that the food of the insect has not become less available at this period. Other common insects which hibernate as larvæ at a definite date irrespective of low temperatures are the Woolly Bear (Isia isabella) and an Arctiid (Apantesis nais). This "habit" was studied in 1915, especially with reference to its independence of stimulii from relative humidity.

The proceedure was as follows: Different relative humidities were maintained by solutions of H_2SO_4 of various sp. gr. as suggested by Woodworth[2] and which I calculated from figures given by Richards.[3] I have plotted the curve below from Richard's figures and used the formula accompanying it in the Volume calculations. (Figure 1).

The solutions (200 cc.) were placed in battery jars (capacity 2000 cc.) with broad ground edges, which were vasalened and covered with a glass plate. Inside these battery jars, supported over the H_2SO_4 by square glass dishes, were placed glass jars with a covering of cloth net in which the caterpillars were kept. Food was introduced daily into the jar and the sulphuric acid solution was changed every two weeks. The effects of different humidities was very apparent on the food introduced. In this work, due to the variation in temperature the humidity of any bottle also varied, but this change being equal in each bottle, the difference between bottles remained uniform. The moisture absorbed from food and insects by the H_2SO_4 is a source of error but not a great one.

The data derived from these experiments are shown in tables II and III.

TABLE II.

APANTESIS NAIS.

No. of Experiment..	9	11	12	13	14	15	16	17	27
Date.....	x/7	x/7	x/7	x/7	x/7	x/7	x/7	x/7	x/7
Number Specimens..	10	10	10	10	10	10	10	10	10
Vapor tention..... (15. = saturation)	9.	15.	5.6	13.5	11.	.5	13.8	.8	1.8
No. molted skins....	13	15	12	10	8	10	14	8	8
Date stopped feeding	x1/1	x1/4	x1/4	x1/29	x1/16	x/18	x1/4	x/16	x/16
Date of first death..	x1/1	x1/1	x/14	x11/2	x1/4	x/14	x/4	x/14	x/14
2nd Humidity..... (vapor tention)	13.8	5.6	15.	15.	15.	15.	5.6	15.	.....
Date.....	x1/11	x1/11	x1/11	x11/4	x1/27	x/18	x1/11	x/18	.....
Eating.....	.....	.....	.....	.....	.....	x/18	.....	x/18	.....
Molts.....	.....	.....	.....	.....	.....	1	.....	1	.....
Date Death.....	x1/20	x1/11	x1/16	.....	.....	x/21	x1/16	x/21	.....
Date not Eating....	.....	.....	.....	.....	.....	x1/27	.....	x1/4	.....

TABLE III.

III–38. Sixteen specimens of Isis isabella caterpillars.

DATE	VAPOR TENTION	BEHAVIOR
x1/20–x1/27	15.0	not eating, 1 molt.
x1/27–x1/29	9.0	" " 0 "
x1/29–x11/2	13.5	" " 0 "
x11/2–x11/7	15.	" " 0 "
x11/7–x11/9	13.8	" " 0 "
x11/9–x11/11	{13.8 15.0}	" " 0 "
x11/11.....	.....	.....First Death.

Table III shows a great regularity in the date at which the caterpillars at the different humidities ceased feeding. This date can be considered as the beginning of hibernation, as no feeding took place later than this and all molting and metamorphosis ceased. Since these larvæ were exposed to a high temperature and had abundant fresh food present it is apparent that high temperature, abundant food and any relative humidity is not sufficient stimulus to overcome the "tendency" of the

insects to hibernate. Table IV gives further support to this conclusion and also indicates that various successive treatments with different humidities are also of no avail. Death was not due to poisoning of the larvæ by fumes given off from H_2SO_4, for *Noctua unipuncta* moths were reared from first stage larvæ at vapor tentions 3.4, 9.0, 11., 13.5, 15.0.

Since larvæ before experiencing winter go into a hibernating condition from which various combinations of the three stimulii high temperature humidity and food cannot "arouse" them, we must conclude that this quiescence is predetermined. The practice of collectors and the experiments of Weissmann,[4] have shown that a period of low temperature makes it possible to activate hibernating insects by high temperature. Kirby and Spence[5] have suggested that this predetermination is instinctive as they observed that before winter insects suddenly at a definite date, independent of weather conditions, start an excited search for winter shelters. This "instinct" has probably been noticed by every collector of insects. However, this "instinct," if not directed by any external stimulus is rather hard to explain in cases where a summer and a winter generation occur.

Pictet[6] studied the *Lasiocampa quercus* and Dendrolimus larvæ which hibernate before the temperature has lowered. In the case of *Lasiocampa quercus*, the adult emerges in July, but larvæ appear in August and hibernate, beginning again to develop in Spring and pupating in June-July. By keeping the larvæ on ice it was possible to cause them to pupate in May. Continued selection of precocious larvæ for six generations decreased the length of larval life from 245 to 112 days. The pupal period was lengthened sufficiently to make up for the difference. Similar experiments with *Dendrolimus pini* gave a second generation and no persistence of the normal cycle. Pictet believes that this difference is due to the fact that *Lasciocampa quercus* feeds on the leaves of deciduous trees, while *Dendrblimus pini* feeds on the leaves of evergreen trees.

We have seen that certain insects have a definite periodical hibernation which is hereditary. This quiescence can only be overcome by a certain period of low temperature and the organisms then by a compensatory lengthening of the next stage regains its normal rhythm. Other insects are more plastic and instead of showing a definite period of hibernation, merely remain quiescent during periods of low temperature and

are active immediately after the temperature is raised. Such insects can be reared all the year round in the greenhouse and may be exemplified by Drosophila, *Noctua unipuncta*, the cockroaches, *Musca domestica* and others. In fact, we have every degree of development of this periodicity.

The factors which have determined the variability of this characteristic may be seen from a survey of some insect life histories. These factors are of three kinds:

1. *Climate.*—As there is no cold period in the tropics, insects do not hibernate there. This lack of periodicity persists in insects introduced into the temperate regions. This is probably the case with Drosophila which cannot be induced to hibernate.

2. *Food.*—Insects which feed upon materials constantly available do not show a definite periodicity. Thus the house fly female will oviposit at any time of the year when the temperature is appropriate. Pictet has pointed out that insects which feed on evergreen trees are not as rhythmical in their hibernation as those which feed on deciduous trees.

3. *Exposures.*—The degree to which insects are each year exposed to the conditions of winter may also determine the elasticity of their periodicity. Thus the Woolly Bear, which hibernates under stones in rather an exposed condition, has a definitely established period of hibernation, whereas the Army Worm, which hibernates deep in the earth, is less exposed to the effects of winter and hence hibernates only upon direct stimulus.

These three factors may also determine the stage or stages in which different species of insects hibernate. The data on life histories contained in Judeich and Nitsche[7] are more available than any others, because the life cycles of different species are tabulated in a system of which I show a modification below. This method makes it possible to record scattered observations on different stages of the life cycle of an insect and finally to read the whole history at a glance. It would be a great advance if a repository for such data could be established at some university or other institution.

LEPIDOPTERA — *Phycis tumidella* Zk.

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
EEE	EEE	EEL	LLL	LLL	PPP	AAA	EEE	EEE	EEE	EEE	EEE

Dist.—Mid. Europe, S. France.
Larvæ—Skeletonize oak leaves, from one side only, working in a tunnel under roof of pcs. of leaves.
Pupæ—In cocoon under ground.
Judeich u. Nitsche, 1895, p. 1060.
Symbols A, E, L, P stands for adult, egg, larva and pupa respectively.

HYMENOPTERA *Lophyrus pini* L.

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
ppp	ppp	ppP	AA EE PAA	*LLL*	*LLL*	PPA E	A E*LL*	*LLL*	*L*pp	ppp	ppp
ppp	ppp	ppP	AA EE EE PAA EE	LLL LLL 1	LLL LLL	ppp PPA E	ppp A 2 ELL	ppp LLL	ppp Lpp	ppp ppp	ppp 1 ppp 2'
ppp	ppp	ppP	PAA	2'							

Symbols as above with addition of "p" for prepupa and numbers for alternating generations and *italicized* to indicate injurious period.

This method of tabulation is more easily read and used than the system sometimes employed by the U. S. Bureau in which a circle represents the whole year and different stages occupy sectors or are shown by spiral lines. In a life cycle that extended over several years, such a method would lead to endless complications.

For the Tortricids of European forests we find by compilation that those species which feed on the outside of the tree hibernate in a resistant stage that is, as eggs or pupæ—whereas those which feed on the inside (protected places) of the tree hibernate as larvæ.

TABLE IV.

SPECIES	FEEDING HABIT	HIBERNATING STAGE
Tortrix		
pinicolana Zll.	Outside on needles of Larch	Egg
murinana Hbn.	Outside on needles of White Fir	Egg
rufimitrana H.Sch.	Outside on needles of White Fir	Egg
viridana L.	Outside on leaves of Oak	Egg
buoliana Schiff.	Inside bud of Pine	Larva
nigricana H. Sch.	Inside bud of Fir	Larva
tedella Cl.	Inside needles of Pine	Larva
duplicana Zett.	Inside twigs of Pine	Larva
pactolana Zll.	Inside twigs of Pine	Larva
turionana Hbn.	Inside buds of Scotch Fir	Larva
strobilella L.	Inside cones of Pine	Larva
resinella L.	Inside bud *gall* of Pine	Larva, two years
zebeana Ratz.	Inside resinous gall of Larch	Larva, two years
duplana Hbn.	Outside on shoots of Fir	Pupa

Again compiling the data on the Noctuidæ from the same source similar results are obtained and it is also shown that food supply is a factor in the determination of the hibernating stage.

TABLE V.

Noctuidæ.

HIBERNATING STAGE					LARVAL FOOD HABIT
Any stage	Egg	Larva	Pupa	Imago	
1			1	2	Polyphagus
	3		4	1	Desciduous trees
			1		Evergreen trees
	1				Borer
		2			Underground

Compiled from life-histories of the following species:

Noctua satellitia L.	Noctua vetusta Hbn.
Noctua exolitia L.	Noctua pisi L.
Noctua piniperda Panz.	Noctua gamma L.
Noctua aprilina L.	Noctua trapezina L.
Noctua ochracea Hbn.	Noctua caeruleocephala L.
Noctua segetum Schiff.	Noctua vestigealis Rott.
Noctua coryli L.	Noctua aceris L.
Noctua incerta Hfn.	Noctua pulverulenta Esp.

In general, we may conclude that insects hibernate as (1) adults, when their food habits are such that oviposition can take place on the proper food at the earliest warm weather (2) as larvæ, when protected from the cold and thus able to continue feeding to the latest date possible, (3) as pupæ or eggs, because they are nonfeeding resistant stages.

There is no evidence available as to whether or not these adaptations were established by selection, mutation, or inheritance of acquired characters. The evidence does, however, show that hibernation has resulted from the repeated effect of winter upon the species and that the degree to which this phenomenon has become rhythmical has been determined by the habits of the insect.

LITERATURE CITED.

1. **Baumberger, J. P.** Ann. Ent. Soc. Amer., 7, 1914 (323-353).
2. **Woodworth, C. W.** Rept. College Agr. & Agr. Expt. St., Univ. Cal., June, 1914.
3. **Richards, T. W.** Proc. Amer. Ac. Arts & Sc., 33, 1897 (23-27).
4. **Weissmann, A.** "Essays on Heredity," 1889.
5. **Kirby, W.** and **Spence, W.** "An Introduction to Entomology," 3d Ed., Vol. II, 1823, London.
6. **Pictet, A.** IXe. Congr. Internat. Zool. Monaco, 1913 (774-778).
7. **Judeich, J. F.,** and **Nitsche, H.** "Lehrbuch der Mitteleuropaeischen Forstinsecktenkunde," Wein, 1895, Vol. I, II.

THE NATURE OF THE VERACERVIX OR NECK REGION IN INSECTS.*

By G. C. CRAMPTON, Ph. D.

Occasional references to the neck as the "labial or microthoracic segment" in recent entomological literature indicate a tendency to revive the old mistaken conception of the neck region of insects as representing the labial segment, or a vestigial segment of the thorax ("microthorax")—a view which dates from the time of Strauss-Duerkheim, 1828, and Huxley, 1885, but for which no real evidence has ever been adduced. It is a simple matter to demonstrate (1) that the neck region is in every way homologous with the other *intersegmental* regions between the true thoracic segments, and therefore cannot represent a segment at all; (2) that like the other intersegmetal regions with which it is homologous, it has no ganglia or any other segmental structures, either in the adult or embryonic stages; (3) that the labium is not its appendage; and (4) that there is already present in the head capsule a labial segment forming that portion of the head region to which the labium is articulated, while the labium is not articulated to the neck plates at all, the latter being formed behind the true labial segment. If these facts were known, there could be no excuse for arbitrarily designating the neck plates as "the labial or microthoracic segment," without giving any reason for justifying such a course of procedure, in the face of the overwhelming evidence that the neck region does not represent such a segment at all; so that it may perhaps be worth while to present the evidence which completely disproves the view that the neck region is a segment either labial or "microthoracic."

The evidence to be adduced from comparative anatomy in regard to the *intersegmental* nature of the neck plates, is most convincing and conclusive. In Fig. 1 the intersegmental plates located in the intersegmental regions designated as "Int" (i. e. regions I, III and V) are shaded so as to enable one to compare them more readily in the different segments, the entire figure being a composite of the conditions found in the most primitive of the Apterygotan and Pterygotan

*Contribution from the Entomological Laboratory of the Massachusetts Agricultural College, Amherst, Mass.

insects. It is at once apparent from a glance at Fig. 1, that the two ventral prothoracic intersegmental plates designated as "*ps*" in intersegmental region I (i. e. "Int. I") are in every way homologous with the two ventral metathoracic intersegmental plates designated as "*ps*" in intersegmental region V (i. e. "Int. V"). In the Plecopteron *Capnia* (Fig. 1) there are two ventral prothoracic intersegmental plates "*ps*" in intersegmental region I, but in the closely related Plecopteron *Leuctra* (Fig. 3) the anterior one of the two ventral prothoracic intersegmental plates "*ps*" has almost disappeared in region I, while

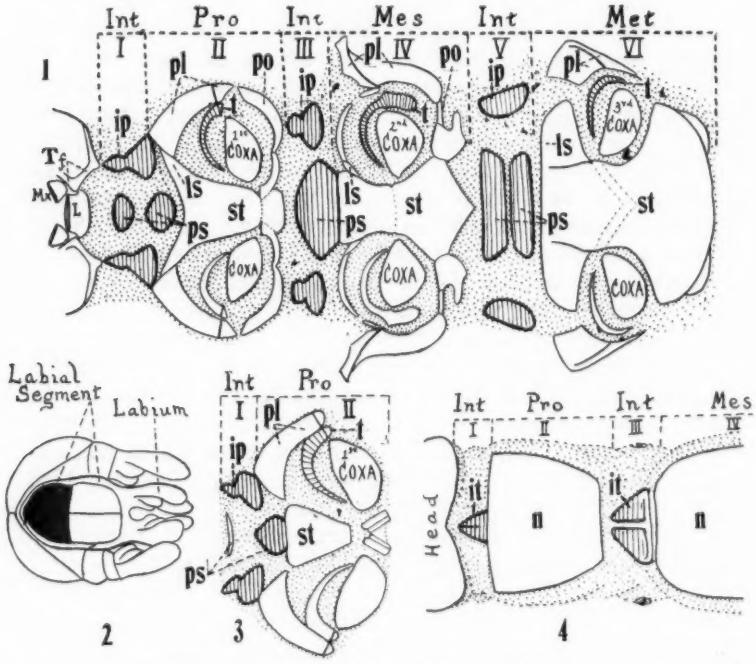


Fig. 1. Lateral and ventral region of the prothorax of **Capnia,** the mesothorax of **Eosentomon,** and the metathorax of **Japyx** drawn as though spread out in one plane. Based, in part, upon figures by Prell, 1913, and Verhoeff, 1904.

Fig. 2. Head of an embryo of **Eutermes,** stage "F," taken from Fig. 28, Plate 3, of paper by Holmgren, 1909. (Figure slightly modified).

Fig. 3. Lateral and ventral regions of prothorax of **Leuctra,** drawn as though spread out in one plane.

Fig. 4. Dorsal view of prothorax and mesothorax of **Japyx,** based on figures from various sources.

the posterior one, "*ps*," is still large, and is connected with the sternal plate "*st*" behind it, as is the case with the ventral mesothoracic intersegmental plate "*ps*" of intersegmental region III, in Fig. 1. It is thus a very simple matter to homologize the ventral prothoracic intersegmental plates "*ps*" (i. e. the neck plates) of intersegmental region I of Figs. 3 and 1, with the ventral mesothoracic and metathoracic intersegmental plates "*ps*" of intersegmental regions III and V, (Fig. 1). In the same way, the lateral prothoracic intersegmental plates "*ip*" of region I are homologous with the lateral mesothoracic and metathoracic intersegmental plates "*ip*" of regions III and V (Fig. 1). Similarly, the tergal prothoracic intersegmental plates "*it*" of intersegmental region I (Fig. 4) are homologous with the tergal mesothoracic (and also with the tergal metathoracic) intersegmental plates "*it*" of intersegmental region III, etc. (Fig. 4).

It is thus a very simple matter even for the veriest tyro in the study of comparative anatomy to homologize intersegmental region I (i. e. the neck region) with intersegmental regions III and V (Figs. 1, 3 and 4), and if comparative morphology has any meaning at all, intersegmental regions III and V

ABBREVIATIONS.

Int—Intersegmental regions between labial segment and prothorax; between prothorax and mesothorax; and between mesothorax and metathorax.
ip—Interpleurites, or lateral intersegmental plates.
it—Intertergites, or dorsal intersegmental plates.
L—Labium.
ls—Laterosternite, or lateral plate of sternum.
Mes—Mesothorax.
Met—Metathorax.
Mx—Maxillae.
n—Notum or tergum.
Pro—Prothorax.
pl—Pleural plate (Eupleuron).
po—Post-coxal plate (Postcoxale).
ps—Intersternites or sternal intersegmental plates, the posterior one being the presternite.
st—Sternum.
t—Eutrochantin.
Tf—Trophifer, or sclerite to which labium and maxillae are articulated.
I—Veracervix, or prointersegment, the first intersegmental region which is largely prothoracic.
II—Remainder of prothorax.
III—Mesointersegment, or second intersegmental region which is largely mesothoracic.
IV—Remainder of mesothorax.
V—Metaintersegment.
VI—Remainder of metathorax.

must also be considered as representing entire segments, if their homologue, intersegmental region I, is taken to represent a distinct segment. Verhoeff, 1902-1903, clearly realized that it was impossible to consider intersegmental region I (i. e. the neck) as a distinct segment, without likewise regarding its homologues, intersegmental regions III and V, as representing entire segments also, since all three regions are in every way exactly homologous. Verhoeff, 1904, therefore boldly accepted the consequences of his assumption, and claimed that the thorax actually consists of six segments, terming the intersegmental regions the "microthorax, stenothorax and cryptothorax," and making them the equivalents of the prothorax, mesothorax and metathorax. Embryology, however, affords no evidence of more than three segments in the thorax, nor does the evidence of comparative anatomy give any grounds for considering that these intersegmental regions represent distinct segments, since none of them contains any ganglia or other segmental structures—as was pointed out by Silvestri, 1902, Boerner, 1903, Desguin, 1908, and others—and no recent entomologist has had the courage to claim that the thorax is composed of more than three segments.

Some entomologists, however, ignoring the fact that intersegmental region I (Figs. 1, etc.) is in every way homologous with intersegmental regions III and V, would maintain that intersegmental region I (i. e. the neck region) *alone* represents a distinct segment, claiming that it is the real labial segment. Since the labium ("L" of Fig. 1) does not articulate with the plates of intersegmental region I, but articulates with the sclerite designated as "*Tf*" (which contains the real labial segment) in the head capsule, these entomologists are forced to the astonishing conclusion that the labium has become detached from its own segment, and, taking along with it the labial neuromere (or labial ganglion) and other characteristic segmental structures, has migrated "bag and baggage" into the head region, leaving behind it the mere shell of the labial segment in the neck region I! Such a disruption and migration of both internal segmental structures and external appendages, which have in some way become detached from their proper segment, and have grafted themselves onto another region, is wholly without precedent in the entire realm of Zoology, for never did such an occurrence take place other than in a labora-

tory grafting experiment, and the mechanism for its accomplishment in nature is utterly incomprehensible. What advantage can there possibly be in rejecting the perfectly obvious, simple and logical explanation of the neck plates as an intersegmental region, similar in every way to the other intersegmental regions of the thorax, and in the place of such a simple explanation, proposing that an unparalleled and unprecedented disruption and grafting experiment has taken place in the labial region alone in all nature, when we know of absolutely no mechanism by which such an operation could be carried out? Always, in the cephalization process, both segment and appendage enter into the composition of the head region, although the appendage may subsequently degenerate, and the segment may become indistinguishably fused with the other segments forming the head capsule.

Since the labium articulates with the head capsule, it is but natural to suppose that the segment which originally bore the labial appendage is included in that region of the head capsule with which the labium articulates, and embryology fully justifies this assumption. As is shown in Fig. 2, which I have adapted from a figure of the embryological development of the head of a Termite by Holmgren, 1909, the entire labial segment of these insects actually enters into the composition of the head capsule of the developing Termite, and does not remain behind to form the neck plates, while its appendages become disrupted and graft themselves upon the head capsule. Furthermore, the neck plates are unusually well developed in the Termites (which are quite closely related to the Blattids), and if these neck plates really represent the labial segment, the fact would be clearly indicated in the development of these insects; whereas, on the contrary, the researches of Holmgren, 1909, and Heymons, 1895-1905, carried out upon a great range of embryos of very primitive insects, conclusively demonstrate that the labial segment enters into the composition of that portion of the head capsule to which the labium is articulated, and which one would naturally expect, from the manner in which all other appendages are articulated to the segment which originally bore them, instead of unnaturally grafting themselves upon some other region!

On this account, I am inclined to regard as a "*lapsus calami*" the including of the neck plates in the labial segment

by Riley, 1904, in his table of the parts of the head of a Blattid embryo. Riley offers absolutely no proof whatsoever, either in his text or figures, for such an assumption, and it is the more inexplicable from the fact that he definitely states that the "pleurite" (i. e. the embryologists' term for pleuron) of the labial segment is in the posterior portion of the embryo's head capsule. The only explanation which suggests itself, is that he must have been unaware of the existence of intersegmental regions III and V (Fig. 1), homologous with the neck plates, and situated between the true segments, in the lower insects, and was thus unable otherwise to account for the presence of the intersegmental plates forming the neck region, unless they were to be regarded as representing the labial segment. Since I have not examined Dr. Riley's material, I do not know what evidence it offered for assuming that the neck plates represent the embryonic labial segment, but, while studying in Berlin, Prof. Heymons allowed me to look over his embryological material, in which I was unable to find any indications whatsoever that the neck plates represent the embryological labial segment; and in view of the direct embryological evidence that the labial segment is included in that portion of the head capsule to which the labium is articulated, I am forced to consider that the including of the neck plates in the labial segment in Dr. Riley's paper, is a minor error in an otherwise extremely carefully conducted and valuable embryological investigation.

I have perhaps laid too great emphasis upon a "side issue" of Dr. Riley's paper simply because, in searching through the appended list of reference works, his is the only recent article I could find, containing original embryological data, in which the neck plates are referred to as the labial segment; and on this account, I have inferred that recent investigators have reference to his work, when they state that there is embryological "proof" that the neck plates are to be regarded as the "labial or microthoracic segment." It seems incredible that any one can seriously put forth as "proof" the mere fact that some investigator has arbitrarily designated the neck plates as the labial segment in his table of the parts of the head, without giving any reasons for so doing, but such seems to be the case, unless these entomologists have reference to some other work which I have not seen.

Now the neck region of an insect is no more a part of the head capsule than the seven cervical vertebrae of mammals are a part of the skull, and it would therefore be wholly incorrect to say that the head of an insect is composed of six segments, if the sixth, or labial segment, remains behind to form the neck region, which is situated back of the head region. It is thus rather surprising to have these entomologists refer to the head of an insect as composed of six segments (including the labial segment) and in the same breath assert that the neck plates behind the head of such an insect are the labial segment. This is assuredly not in conformity with the laws of physics, which assert that a single body cannot occupy two different positions at one and the same time! If the labial segment is in the head region, it simply cannot be in the neck region behind the head region; and when such embryologists as Heymons, Holmgren, Hirschler, Hoffman, Philiptschenko, Strindberg, and every other recent embryologist, with the exception of Riley, are unanimous in asserting that the labial segment is in the head capsule, it would appear that there is some reason for considering that the labial segment is really in the head capsule and not in the neck region behind the head! Heymons and Holmgren have very carefully traced out the portions of the head which are formed by the embryonic labial segment, and I can see no reason for regarding their work as wholly false, especially since it is borne out by the facts of comparative anatomy and is in accordance with the known zoological phenomena. We are thus justified in stating that the only actual embryological proof thus far brought forward, conclusively demonstrates that the labial segment enters into the composition of the head capsule, and consequently the neck plates must be interpreted as intersegmental plates between the real labial segment and the prothoracic segment, homologous with the other intersegmental plates between the other thoracic segments.

Those who maintain that the neck plates are the labial or microthoracic segment, must bring forward some actual proof for their claim. They must prove the falsity of the embryological evidence brought forward by such embryologists as Holmgren, 1909, who have shown that the embryonic segment depicted in Fig. 2 is the labial segment, or they must explain in some other way the presence in the head capsule of an

embryonic segment to which the labium is articulated. They must explain why there are six segments in the head, if the sixth or labial segment remains in the neck region behind the head, to form the cervical sclerites. They must explain the presence in the head region of the labial neuromere. They must explain the lack of segmental structures in the neck region if it is really a "labial or microthoracic segment." They must explain why in the neck region alone in the whole realm of Zoology, a pair of appendages have detached themselves from the supposed segment which originally bore them, and have grafted themselves upon another region; and the description of the hitherto unknown mechanism by which this unique event was brought to pass, will be a distinct contribution to science! Unless they are prepared to admit that the other intersegmental regions (III and V of Fig. 1) were made to appear to be homologous with the neck plates (region I) merely for the purpose of deceiving the unwary, they must grant that these other intersegmental regions between the thoracic segments are also distinct segments, if they claim that the neck region (with which they are in every way homologous) is a distinct segment, either labial or "microthoracic." They must then explain why these new "segments" have no segmental structures, and why embryology offers no indication of their segmental nature. Indeed, the difficulties in the way of accepting the view that the neck plates represent a "labial or microthoracic segment" are so numerous and insuperable, that it is astonishing that any one would deliberately adopt such an utterly unfounded hypothesis and disregard the obvious explanation of the neck plates as an *intersegmental* region between the true labial segment and the prothorax, just like the other intersegmental region between the thoracic segments—a view which, unlike the "labial or microthoracic segment" hypothesis, postulates the occurrence of no hitherto unparalleled phenomenon, involves the operation of no inexplicable mechanism, is in complete accord with all of the observed facts of embryology and anatomy, and is the simplest and most logical explanation thus far advanced to account for the occurrence of the neck plates. On this account we are justified in assuming that the neck plates do not represent a segment either labial or "microthoracic," and it is consequently incorrect to designate them as such.

The term collum is applied to the narrow posterior portion of the head region or to the entire prothorax, by Coleopterologists, and the designation jugulum is applied to the gular region of the head, or to the sides and sternum of the prothorax, so that neither of these terms is available for the true neck region. Since the neck plates are universally designated as the cervical sclerites, the term cervix would be singularly appropriate for the region in question. Dipterologists, however, have very inconsiderately applied the term cervix to the upper portion of the hinder head region in certain flies, and the same term is applied to the posterior constricted neck-like region of the head in other insects, in which the true neck region is also present, so that it would merely create confusion to apply the designation cervix to the true neck region. In order to preserve some form of the term cervix, which is implied in the universally accepted designation cervical sclerites, the neck region was referred to as the veracervix or "cervicum" (Crampton, 1908-1914, Snodgrass, 1910, Martin, 1916) and the former term has been retained in the present paper.

The intersegmental plates between the other thoracic segments are not preserved in many Pterygotan insects. Traces of them occur between the prothorax and mesothorax of *Corydalis cornutus*, between the prothorax and mesothorax of the earwig *Doru luteipennis* (the unknown Forficulid shown in Plate 3, Fig. 19, by Crampton and Hasey, 1915), and in certain Plecoptera and Homoptera. It is in the Apterygotan forms, however, such as *Japyx* and *Eosentomon* (Fig. 1) that the intersegmental plates are best preserved between the thoracic segments, and since these are among the most primitive of living insects, we are justified in assuming that the conditions which they present approximate the original one, in many respects.

In *Japyx* and *Eosentomon* (Fig. 1) the eutrochantin "*t*" intervenes between the coxa and the pleural plate "*pl.*" This condition is preserved in the prothoracic region (i. e. in the non-wing-bearing segment, which is consequently the least modified and the most like the segments of the Apterygotan forms) of many of the most primitive Pterygotan forms such as the Plecoptera, Embiids, certain Forficulids (*Allostethus*) Grylloblattids, Termites, etc., so that I would now consider this condition as representing the original one, and have therefore

designated the plate "*t*" (Fig. 1) as the eutrochantin, or true trochantin, instead of the "pseudotrochantin," which I formerly considered it to be (Crampton and Hasey, 1915). This point, however, will be discussed more at length in a subsequent paper.

BIBLIOGRAPHY.

1893. **Banks**—Notes on the Mouth Parts and Thorax of Insects, in: Amer. Nat., Vol. 27.
1904. **Banks**—Notes on the Structure of the Thorax and Maxillae of Insects, in: Proc. Ent. Soc. Washington, Vol. 6, p. 149.
1865. **Basch**—Untersuch. u. d. Skelet u. d. Muskeln des Kopfes von Termes, in: Zeit. Wiss. Zool., Bd. 15, p. 56.
1905. **Bengtsson**—Z. Morphologie des Insektenkopfes, in: Zool. Anz. Bd. 29, p.457.
1903. **Boerner**—Kritische Bemerkungen ueber einige vergl. morphologische Untersuchungen K. W. Verhoeff's, in: Zool. Anz., 26, p. 290.
1904. **Boerner**—Z. Systematik der Hexapoden, in: Zool. Anz., Bd. 28.
1897. **Carriere & Buerger**—D. Entwicklungsgeschichte der Mauerbiene, in: Nova Acta Akad. Leop. Carol. Naturf., Bd. 69, p. 255.
1902. **Comstock & Kochi**—The Skeleton of the Head of Insects, in: Amer. Nat., 26, p. 13.
1908. **Crampton**—Ein Beitrag z. Homologie d. Thorakal-Skerlite der insekten, Diss. Berlin.
1909. **Crampton**—A Contribution to the Comparative Morphology of the Thoracic Sclerites of Insects, in: Proc. Acad. Nat. Sciences, Phila., 1909, p. 3.
1914. **Crampton**—The Ground Plan of a Typical Thoracic Segment in Winged Insects, in: Zool. Anz., 44, p. 56.
1914. **Crampton**—Notes on the Thoracic Sclerites of Winged Insects, in: Ent. News, 25, p. 5.
1915. **Crampton & Hasey**—The Basal Segments of the Leg in Insects, in: Zool. Jahrb., Abt. Anat., Bd. 39, Heft 1, p. 1.
1908. **Desguin**—La composition segmentaire du thorax des Insectes, in: Ann. Soc. Ent. Belgique, 52, (3), p. 113.
1907. **Enderlein**—U. d. Segmental-apotome der Insekten, etc., in: Zool. Anz., Bd., 31.
1899. **Folsom**—The Segmentation of the Insect Head, in: Psyche, 8, p. 391.
1899. **Folsom**—The Anat. & Physiology of the Mouth Parts of the Collembolan Orchesella, in: Bull. Mus. Comp. Zool. Harvard, 36, p. 87.
1900. **Folsom**—The Development of the Mouth Parts of Anurida, in: Bull. Mus. Comp. Zool. Harvard, Vol. 36.
1904. **Haller**—U. d. allgemeinen Bauplan des Trachaetensycerebrums, in: Arch. Mikr. Anat., 65, p. 181.
1895. **Heymons**—D. Segmentirung des Insektenkoerpers, in: Kgl. Preuss. Akad. Wiss. Berlin Anhang.
1895. **Heymons**—Embryonalentwicklung von Dermapteren u Orthopteren, Jena.
1896. **Heymons**—B. z. Entwicklungsgeschichte der Insekten Apterygota, in: Sitzb. Akad. Berlin, Bd. 51.
1896. **Heymons**—G. d. Entwicklung u. d. Koerperbaues von Odonaten u. Ephemeriden, in: Abh. K. Preuss. Akad. Wiss. Berlin, Anhang.
1897. **Heymons**—U. d. Zusammensetzung des Insektenkopfes, in: Sitzb. Gesell. Naturf. Fr. Berlin.
1905. **Heymons**—D. Entwicklungsgeschicte von Machilis, in: Verh. Deutsch. Zool. Gesell. Leipzig, 15, p. 123.
1905. **Heymons**—Review of paper by Verhoeff, 1905, on head of insects, in: Zool. Centralbl., 12, p. 539.
1909. **Hirschler**—D. Embryonalentwicklung von Donacia, in: Zeit. Wiss. Zool., XCII, p. 627.
1911. **Hoffmann**—Z. K. d. Entwicklungsgeschichte der Collembolen, in: Zool. Anz., 37, p. 353.

1904. **Holmgren**—Z. Morphologie des Insektenkopfes, I, in: Zeit. wiss. Zool., 76, p. 439.
1904. **Holmgren**—Z. Morphologie des Insektenkopfes, II, in: Zool. Anz., Bd. 27.
1907. **Holmgren**—Z. Morphologie des Insektenkopfes, III, in: Zool. Anz., 32, p. 73.
1909. **Holmgren**—Termitenstidien I, Anatomische Untersuchungen.
1913. **Hosford**—Segmentation of Head of Insects, in: Kans. Univ. Bull., Vol. 8.
1878. **Huxley**—Manual of the Anatomy of Invertebrate Animals.
1906. **Imms**—Anatomy and Development of Anurida, in: L. M. B. C. Memoir 13.
1899. **Janet**—Essai s. l. constitution morphologie de la tete de l'insecte, Paris.
1893. **Kolbe**—Einfuehrung i. d. Kenntnisse d. Insekten.
1893. **Korschelt & Heider**—Lehrbuch.
1830. **Macleay**—Explanation o. t. Comparative Anatomy o. t. Thorax in Winged Insects, in: Zool. Jour., Vol. 5, No. 18.
1916. **Martin**—T. Thoracic and Cervical Sclerites of Insects, in: Ann. Ent. Soc. America, 9, p. 35.
1880. **Meinert**—S. l. conformation de la tete etc. chez les insectes, etc., in Ent. Tidsk. arg. 1., p. 147.
1880. **Packard**—T Number of Segments in the Head of Winged Insects, in: 3d. Rpt. U. S. Ent. Comm.
1898. **Packard**—Textbook of Entomology.
1907-1912. **Philiptschenko**—B. z. K. der Apterygoten in: Zeit. Wiss. Zool., LXXXVIII, p. 99-; XCL, p. 93-; CII, p. 519.
1913. **Prell**—D. Chitinskelett von Eosentomon, in: Zoologica, Heft 64.
1904. **Riley**—T. Embryological Development of t. Skeleton o. t. Head of Blatta, in: Amer. Nat., 38, p. 776.
1863. **Schaum**—U. d. Zusammensetzung d. Kopfes, etc., bei den Insekten, in: Arch. Naturg. Jg. 29, Bd. 1, p. 247.
1902. **Silvestri**—Einige Bemerkungen u. d. sogenannten mikrothorax d. Insekten, in: Zool. Anz. Bd. 25.
1909. **Snodgrass**—The Thorax of Insects, etc., in: Proc. U. S. Nat. Mus., Vol. 36.
1910. **Snodgrass**—The Thorax of the Hymenoptera, in: Ibid. Vol. 39.
1910. **Snodgrass**—The Anatomy of the Honey-bee, in: U. S. D. A. Bur. Ent. Tech. Ser. No. 18.
1828 **Strauss-Duerkheim**—Consid. gen. l'anatomie comparee des animaux articules.
1902. **Verhoeff**—Ueber Dermapteren. u. ueber den Mikrothorax der Insekten, in: Zool. Anz. Bd. 25.
1902. **Verhoeff**—U. d. Nerven d. Metacephalsegmentes, etc., in Zool. Anz. Bd. 25.
1903. **Verhoeff**—B. z. vergl. Morphologie des Thorax der Insekten, etc., in: Nova Acta K. L. C. deuts. Akad. Nat., Bd. LXXXI.
1903. **Verhoeff**—Intercalarsegmente der Chilopoden, in: Arch. Naturg., Bd. LXIX.
1904. **Verhoeff**—U. vergl. Morphologie des Kopfes niederer Insekten, in: Nova Acta Kais Leop. Carol. Deutsch. Akad. Naturf. Bd. LXXXIV.
1904. **Verhoeff**—Z. vergl. Morphologie u. Systematik der Japygiden, in: Ibid, Bd. LXX.
1886. **Viallanes**—La morphologie du squelette des Insectes, in: Bull. Soc. Phil., Vol. 10.
1904. **Voss**—U. d. Thorax von Gryllus, in: Zeit. Wiss. Zool., LXVIII.
1900. **Walton**—The Basal Segments of the Hexapod Leg, in: Amer. Nat., Vol. 34.
1893. **Wheeler**—Contribution to Insect Embryology, in Jour. Morphol., Vol. 7.

THE ECOLOGY OF BUBONIC PLAGUE.

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When I entered for the first time the office of the Chief Sanitary Officer of the Isthmian Canal Commission, I saw a large wall chart, the curve of which told exactly how much malaria there was each month on the Canal Zone, expressed as a percentage of the entire working force. This was six years ago. This chart registered the splendid results obtained by the sanitation corps of the I. C. C.; it showed how, although the working force was increased yearly, the malaria rate kept declining yearly. Today malaria is practically exterminated.

This curve showed me more than merely the results of anti-*Anopheles* measures. It showed a definite, seasonal rise and fall in the rate. Malaria was at its lowest from about November or December until April or May, and reached its crest in July. It was the lowest during the dry season, and highest during the wet. Malaria began to shoot upward just after the first heavy rains had fallen. When the dry season approached, the rate fell rapidly. If the dry season was late in coming, then malaria behaved accordingly. The critical factor here is moisture.

The bulk of this malaria is transmitted by *Anopheles albimanus* Wiede., and its racial variety *tarsimaculata* Goeldi. They breed extensively during the wet season. Field inspections show rapid increase in the number of breeding places just as soon as the rains start in. During the dry season it is very difficult to find larvæ of these species. Instead of them, we find plenty of *A. pseudopunctipennis* Theob., a species apparently unimportant in the transmission of malaria on the Isthmus. *Albimanus* is a wet season species; *pseudopunctipennis* is a dry season species. Maximum humidity, maximum malaria and maximum numbers of transmitors of malaria coincide as to time.

In addition to this, it must be noted that the advent of the first heavy rains means also that the workmen get wet, either going to or from their work, or even while working. This means a lowering of their bodily resistance, a factor which is extremely important for the early rise of human malaria.

It appeared to me desirable to learn if such ecological relations could be traced with any of the other diseases directly transmitted by arthropods, especially bubonic plague. World's commerce is becoming so extensive that very soon it will become imperative to open up territories now almost closed to us on account of the presence in them of plague. Quarantine measures are efficacious, but they are also quite expensive because much time is lost. We must fight the plague wherever it occurs. We must get rid of it. This can be done and the cost is relatively low. The study of the ecological relation in plague should reveal to the sanitary officer not merely the kinds of measures he must adopt in order to obtain quick and telling results, but also *when* to employ these measures, and just *where* they must be used in order to obtain maximum efficiency.

I found very valuable data on bubonic plague in the many "Reports on Plague Investigations in India," published in the Journal of Hygiene. During twelve years plague claimed five million victims in India. A trifle over two a minute died during the year 1907! The chart appended to my notes is taken from one of these reports. Other regions where plague is endemic may have a different set of conditions from those in India. These conditions must be well known before the inter-relationships between rat, flea and plague are properly understood and correlated.

A. Plague and Climate.

1. *Bombay City.*—Its climate is hot and dry, the daily mean temperature being from 70° to 80° F. The average diurnal range in only 12.5° F. The S.W. monsoons appear from May to October, and they bring the rains. These rains are heaviest from June to August. The N-E monsoons, which blow from November till April, bring very little or no rain.

The plague epidemic begins in January, rises gradually until it reaches its maximum in March, then declines to a "normal" about the middle of May. Charts which were kept for ten consecutive years show *plague mortality lowest when humidity was highest*, (June to September), and that an almost automatic recession from the maximum takes place as soon as the humidity begins to rise. The mean temperature at the beginning of the rise is from 72° to 75° F., but as soon as it

reaches 78°-80° F., mortality drops off. Slight recrudescence may occur during May to October, i. e., when a fall in the mean temperature occurs. It should be borne in mind, however, that the single factor temperature is not the critical one; it is rather the resultant humidity which counts.

2. *Poona City and Cantonments.*—It is 80 miles from Bombay, 2,000 ft. above sea level, and has a daily mean temperature of from 70° to 80° F., with an average diurnal range of 22.5° F. From May to October it is subjected to the S-W monsoons, but the rainfall (March to June) is less than that of Bombay. June is the hottest and dryest month, its daily mean temperature being from 83° to 90° F. In July the daily mean is from 75° to 80° F., with S-W breezes. The winter months have a daily mean of about 70° F., and an average diurnal range of about 30° F.

The plague epidemics occur between August and March. The charts show that *mortality increases rapidly as the humidity recedes from its maximum crest.* The period of high plague mortality is relatively short, dropping off as soon as the humidity rises.

3. *Nagpur City.*—It is in the Central Province and resembles much Poona, excepting that its mean temperature is slightly higher. Its hot season is from March to June, the mean temperature being from 85° to 95° F. During July to September the temperature is a little over 80° F., while during the cold months (November to February) it is from 70° to 75° F. The rainfall occurs from June to September, and ranges from 40 to 60 inches.

Plague epidemics were most favorable from November to March, and the charts again show *plague mortality lowest when humidity was highest.*

4. *Belgaun City.*—This is in the extreme south of Bombay Province, 2,500 ft. above sea level, and 75 miles inland from the West coast of India. The mean temperature from June to February is from 70° to 75° F., with an average diurnal range of 20° F. March to May is the hot period, the daily mean being about 80° F. The rains occur mostly from June to October, and amount to about 40 inches.

Epidemics begin in July or August and reach their maximum in October. The charts show *plague rising rapidly as soon as the humidity retreats from its maximum.*

5. *Lahore City.*—It is 700 ft. above sea level. It is not within the hot mansoon belt. The rainfall is slight, amounting to about 20-25 inches, and occurs chiefly from July to September. Some rain falls at times during January and February. From November till March the daily mean temperature is below 70° F., in January as low as 54° F. The remainder of the year is above 70° F., from May to August as high as 85° F. to 95° F. The average diurnal range is 27.5° F. (April to May it is 32.5°, and October to November it is 35°.)

Plague epidemics occur from March to May. There is a tendency to recrudescence during the winter months. *Plague mortality rises rapidly as the humidity recedes, but as soon as the humidity begins to rise, the epidemic is quickly terminated.*

6. *Rawalpindi City and Cantonments.*—Situated at the base of the Himalayas, 1,700 ft. above sea level, it has an average diurnal range of from 20° to 30° F. Its hot weather comes from May to August, with a mean temperature of from 80° to 92° F. The rainfall, mostly from July to September, amounts to but 30 or 40 inches. About eight inches of rain falls during the winter season, January to April.

The plague epidemic is from September to November, with slight recrudescence practically throughout the year. *The major epidemics rise rapidly as the humidity recedes.*

7. *Summary:* The authors of the several articles from which these notes were taken, draw certain conclusions, which in brief are: That a temperature of 85° to 90° F., or one of 50° or less, are very unfavorable to plague. This holds true for Bombay City, but does not for Poona and other cities. The truth of the matter is that no one factor alone may exert such wide influences, but that it is rather a resultant of several factors—in this case it is *humidity.* When plague mortality and humidity are placed on the same chart, it becomes at once evident that there is a direct relation between the two.

We shall see a little later on, that *the severity of an epidemic of bubonic plague bears a direct ratio to* (*a*) *flea prevalence and* (*b*) *to humidity.*

B. Fleas.

The investigators in India report that a temperature above 80° F. affected the conditions to which the bacillus was subjected in the flea's stomach. At high temperatures the bacillus

disappears from the stomach more quickly than at lower temperatures, i. e., 70° to 80° F. They found fleas remained infective for longer periods at lower temperatures. A temperature of 50° or less, may directly influence plague prevalence. Fewer rats were found with developed septicaemia at low temperatures than at higher ones.

From an explanatory standpoint these facts mean that due to heat, frequent evacuations take place in the flea, and as a result of this, the bacillus in the digestive tract of the flea is filtered out with greater frequency.

Another excellent observation was that high temperatures retarded both egg deposition and development, and that low temperatures prolonged the life cycle. This should be humidity because high temperatures in India were associated always with high humidity. Humidity, then, is inimical to the flea. The chart shows fleas at their greatest abundance from February to May, their numbers dropping off rather sharply after May, and the cause of this is the humidity which is on the increase from June to August.

Nearly all reports on plague show that its maximum coincides with the period of maximum numbers of fleas. Kitasato (1909) finds that the absolute and relative abundance of *X. cheopis* is much increased during the autumn, i. e., during the plague season. Tidswell (1910) gives a table of the flea population per month per one thousand rats, the average mean monthly temperature, and the average mean monthly humidity; the flea abundance corresponds with the plague season.

The chart for Bombay shows the fleas on *M. decumanus* increase in numbers from June to August, outnumbering those on the black rat. This period is one of heavy rains, and these drive the brown rat from its subterranean burrows, cellars, etc., and force them into dwellings, i. e., into drier situations. Rat breeding increased at this time, due to the ravages of plague among them during the previous months. This influx of rats into a drier habitat is most favorable to the rapid development of fleas.

Quite naturally, the houses in the barrios which are near wharves, etc., may show slight recrudescences of plague at a time when plague in general had declined.

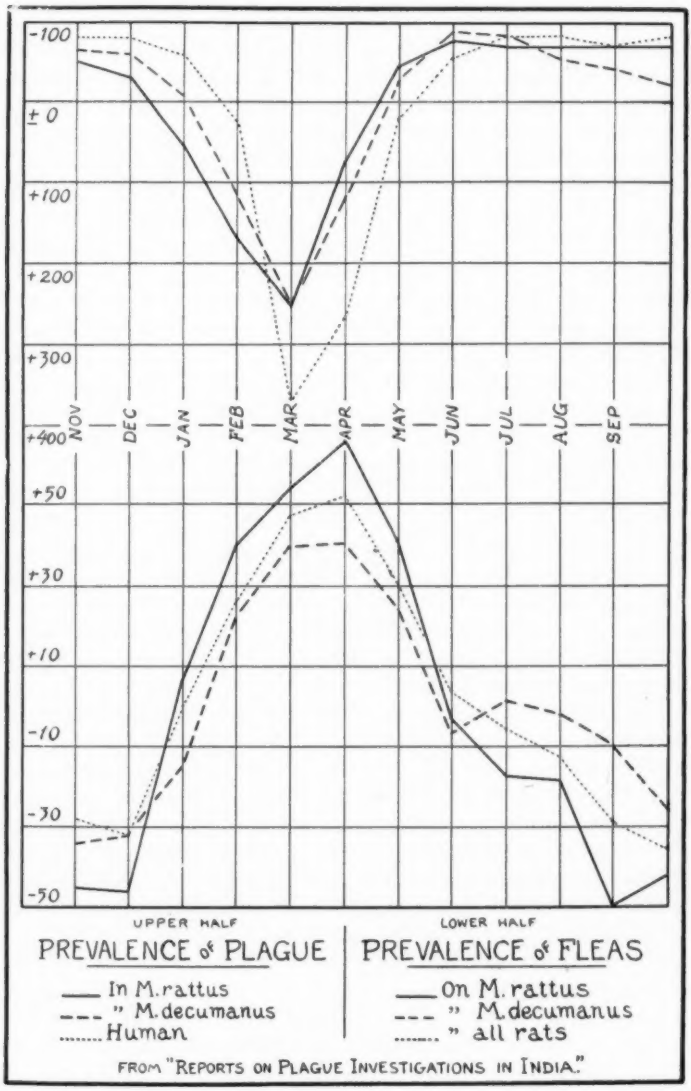
C. Rats.

During November to February, the winter season at Punjab, rat breeding was at its lowest; this is a pre-epizootic period. During the rest of the year the portion of pregnant females to non-pregnant ones was always at or above the mean. Breeding was most vigorous during April, September and October. The plague season was from February to June. At Bombay, the brown rat, *M. decumanus*, breeds the year round, least from December to February, a pre-epizootic period. During March, July, August and October, breeding was most vigorous. The plague epizootic among the rats begins in January, rages during February and March and rapidly declines in April. The same held true with the black rat, *M. rattus*.

The effects of plague are very evident at first among the large numbers of the rats that die; this means there is a super-abundance of rats non-immune to plague. But later on in the stage, there appear quite a number of immune rats, and these furnish the start for the next increase, plenty of young, susceptible rats for the next plague rise. The influence of plague in the rat association is in the nature of a radical disturbance of equilibrium. The reports show very nicely how, after a large percentage of the rats had succumbed to plague, there came a vigorous breeding spell. This sudden breeding-fit is but a natural effort to re-establish again a relative equilibrium. The habitat remained favorable throughout.

Jennings (1910) found 2.20 fleas per each norway rat (*Mus norvegicus*) he examined, and 3.61 fleas per each black rat (*M. rattus*). The difference is not due to the texture of the fur in the two species, but rather to the nesting habits of the two species. The norway rat is more ferocious and its burrowing habit is more pronounced. It constructs its tunnels anywhere it can, mostly where it is moist. The black rat, on the other hand, builds its nests above the ground, in the walls of buildings, etc., consequently in a drier habitat. Moisture is inimical to the flea larva and adult, and therefore the greater number of fleas on the black rat.

Heavy rains affect rats and fleas. They drive them from the wet or submerged burrows into drier situations, and this means closer contact with people as well as increased flea breeding.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UPPER HALF
PREVALENCE of PLAGUE
In M. rattus
" M. decumanus
Human
LOWER HALF
PREVALENCE of FLEAS
On M. rattus
" M. decumanus
" all rats
FROM "REPORTS ON PLAGUE INVESTIGATIONS IN INDIA."

Gauthier and Raybaud (1903) find that the Indian Plague flea, *X. cheopis*, constituted 25% of the flea population upon ship rats at Marseilles, and that the numbers rapidly became fewer as the distance of a locality from the docks increases. Jennings (1910) found that 97.9% of the fleas on rats examined by him at Panama were the Indian plague flea. We have no plague endemic in the Canal Zone (thanks to efficient quarantine), but we have everything favorable to plague epidemics—the right fleas, plenty of rats, and a wet and dry season.

D. The Plague Association.

The severity of an epidemic of bubonic plague was shown to depend upon flea abundance and upon humidity. Fleas are abundant if rats are abundant, and humidity is the critical factor determining at what time of the year fleas are most abundant. The reports of the plague commission show that at Bombay City rat breeding was at its minimum when humidity was lowest, and vice versa, it was most vigorous when humidity was highest. Plague was highest when humidity was lowest, and large numbers of rats were killed off, leaving only a few immune ones with which to start the next progeny. As plague dropped off, and to readjust the loss of equilibrium in the rat world, there followed a vigorous breeding spell. This is with humidity high. A new colony of non-immune rats resulted. The rat epizootic began in January and declined in April. During this period fleas reached their maximum.

Referring to the chart for a moment: Fleas on all rats were at a maximum in March and April. Plague mortality in rats reached its culmination in March. The fleas which left their dead hosts increased plague among human beings from about plus 20 to plus 360 *within one month!* From May on, plague recedes; this is the period of the S-W monsoons, the rain winds.

The chart shows more fleas on the black rat, *M. rattus*, than on the brown rat. This was found true on the Canal Zone by Jennings. It places the black rat into greater importance with respect to the transmission of human plague. This rat is the common Canal Zone rat; so is *X. cheopis* the common flea, whose natural host is the black rat.

These notes show that *the severity of an epidemic of bubonic plague bears a direct ratio to* (*a*) *flea abundance and to* (*b*) *humidity.* This holds true for India. No doubt it holds true for other places where bubonic plague is endemic. The same set of conditions may not be duplicated elsewhere, but the ecological relations will in the main part correspond to those of India.

I am indebted to Dr. S. T. Darling, formerly Chief of the Board of Health Laboratory of Ancon Hospital, for the use of his library.

1903. **Gauthier & Raybaud.** Revue d' Hygiene, XXV, p. 426.
1908. **Indian Plague Commission.** Journ. of Hygiene, Vol. VIII and IX.
1909. **Kitasato.** Trans. Bombay Med. Congress, p. 93.
1910. **Tidswell.** Rpt. of the Gov. Bur. of Microbiology for 1909 (Sydney) p. 20.

1910. **Jennings.** Rats and Fleas in Relation to Bubonic Plague, with Special Reference to Panama and the Canal Zone. Mt. Hope, C. Z.

THE INTRODUCTION OF SCOLIA MANILAE ASHM. INTO THE HAWAIIAN ISLANDS.

By F. Muir, Hawaiian Sugar Planters' Association.

In July, 1912, the presence of *Anomala orientalis* (Waterhouse) was first recognized in the Hawaiian Islands, where it was found injuring the roots of sugar-cane. There are reasons to believe that it was introduced into the archipelago, probably in the soil of potted plants from Japan, more than four years before its presence was discovered. Although in 1912 it was confined to a comparatively small area, yet it was too widely spread to hope to exterminate it by drastic measures. As the use of insecticides did not prove any more successful here than elsewhere, it was decided to try and introduce insect enemies known to attack Scarabaeidæ in other parts of the world.

In judging of the probable utility of such enemies, it must be borne in mind that the biological environments of the Hawaiian Islands are very unique. Although the native insect fauna is rich in species of several groups, there are several large groups totally unrepresented. The whole of the great complex of the Lamellicornia is only represented by a single genus of Lucanidæ (*Apterocychus*) with a few allied species confined to Kauai, the most isolated and north westerly Island of the group. Of the enormous family of Scarabaeidæ not a single species is native, and there are good reasons to believe that the few species that are present have been introduced since the advent of the white man. *Adoretus tenuimaculatus* Waterhouse (known locally as the Japanese or rose beetle) was introduced from the Orient about 1896 and is one of the worst garden pests in the Islands, making the growing of roses in the lower and dryer districts very difficult, and spoiling the looks of many of the ornamental shrubs, on account of the ravages of the adult insect. The natural corollary of these conditions is the total absence of all the natural specific enemies of the Scarabaeidæ, such as *Scolia*, *Tiphia*, *Presena*, etc., which play an important part in keeping these beetles in check in other parts of the world; also the absence of those Mutilids, Bombyliids, Rhipiphorids, etc., which are known to attack the above parasites. It is this simplicity of biological environments

that has, above everything else, made the controlling of certain insect pests by introduced insect parasites the success that it is.

Early in 1913 one of the members of the H. S. P. A. Experiment Station proceeded to Japan and eventually to Formosa, Java and the Philippines, to study the death factors of *Anomala*, *Adoretus* and allied "white grubs." The work is still in progress but as this is the first record of the successful introduction and establishment of a *Scolia* in a new region a brief statement of the establishment of *Scolia manilæ* Ashm. in Hawaii may be of interest to others working on similar problems.

This insect was described by Ashmead from specimens collected by Father Brown in the Observatory Gardens in Manila. It is very common in the grounds of the College of Agriculture at Los Banos, some forty miles from Manila, and it was here that most of our work was done. The Dean of the College very kindly placed the college insectary at our disposal and assisted us in every possible way.

After experimenting with different methods of handling the parasite we eventually adopted the following methods: A small quantity of soil was placed in the bottom of a small jelly jar with a tin cover, two *Anomala* or *Adoretus* grubs were placed in the soil, a twig of *Alternanthera versicolor* sprinkled with water and a few drops of honey was stuck in the soil and a female *Scolia*, caught in the field, was placed in the jar. After twenty-four hours the jars were turned out and each grub which bore an egg was placed in an artificial mud cell and the entrance closed with mud; the cells were packed in moist soil in tins with tight-fitting lids, and the tins in wicker baskets or boxes were shipped from Manila to Honolulu. By the time that they reached Honolulu the Scolias had pupated, and the cocoons were then placed in damp moss and the adults, when hatched, mated in captivity; a certain proportion were turned out in the field and a proportion retained for breeding. The mating was easily accomplished by confining a female in a sleeve-cage with a number of males and placing the cage in the sun. When shipping by direct or fast boats no Scolia hatched out during the voyage, but by more circuitous routes or by slow boats, a larger or smaller percentage would hatch out and die. On an average, sixty per cent. of the eggs placed in cells went through

to pupæ. For a time we tried placing the cocoons in glass tubes packed in moss, but this method of shipment was not so successful.

The length of the life cycle varied considerably. In Los Banos the average was about 40 days, shortening by a week or ten days under favorable conditions in the summer and lengthening to two months or more in the dry winter months. A similar variation takes place in Honolulu, some specimens having been three months in the cocoon. Small differences of temperature and moisture appear to effect them, especially in the resting larval or early pupal stages.

On one occasion a consignment of adult *Scolias* and *Tiphias* was brought over in a cage with growing *Alternanthera*, but this method could only be used successfully when the cage was accompanied by some qualified person, as the insects require proper attention as to moisture and food.

Between December, 1915 and January, 1917, 6,578 eggs, pupæ and adult Scolias were shipped from Manila and 1191 living females and 973 living males arrived or hatched in Honolulu. Of 1691 cocoons shipped in glass tubes or moss 101 females and 54 males hatched in Honolulu; of 3884 eggs sent in mud cells, 1057 females and 908 males hatched out in Honolulu. These figures do not include those that issued during the voyage and died.

On March 13, 1916, one hundred and fifty cocoons received from Manila were buried in a field where *Anomala* larvæ were abundant. Subsequently those were dug up and it was found that thirteen adults had issued. August 2, 1916, one female and six males and on September 9 sixteen females and twenty-two males were liberated in the same locality. On September 16, the insects were found flying about in numbers that clearly indicated that they had become well established and were increasing rapidly. In January, 1917, they were so numerous in this locality that it was possible to catch as many as 175 females in one morning, and as many as 1606 females were caught during seventeen visits of a couple of hours each, and no diminution was observed, as more were caught on the last day than on the first. These were used to colonize other localities. If males had also been taken, six or seven times this number could have been caught. In other localities where colonies were liberated the Scolia is now known to be established.

It will not be possible to estimate the ultimate effect of this parasite upon the *Anomala* problem before the end of the present year, but the prospects are good. As *Scolia manilæ* attacks *Adoretus* as well as *Anomala*, we hope that it will be beneficial in our gardens as well as in our cane fields.

During the course of this work we have experimented with several species of *Tiphias*, two species of *Prosena*, a *Dexia*, and a *Campylotheca*, also with several predators. Up to the present we have not succeeded in establishing any of these in Hawaii. In Japan there is a species of Asilid fly which is very active in the larval stage, attacking the larvæ of *Anomala*, and in the adult stage attacking the adult beetle, but we have had to eliminate this from our work as it is also very active against bees.

Bacteria acting upon the grubs have been found in all the countries in which we have carried on our work and it plays an important part in keeping a check upon Lamellicorn grubs. In Hawaii it has been noticed, and I have similar experience elsewhere, that a field badly infected with Anomala grubs will recover and be comparatively free for a period, and the writer has reasons to suspect that in some cases this is due to the accumulated bacteria in the soil making it too unhealthy for the grubs.

Fungus is also very effective in wet districts, and in dry districts during the wetter season.

Efforts were made to find an egg parasite and many thousand of eggs were placed in various situations, but without results. Ants and terminates attacked the eggs as well as the usual coleopterous predators.

After three years study of the death factors acting upon these beetles in Japan, Formosa, Java and the Philippine Islands the writer concludes that the problem is a complex one. The death rate is far highest among the eggs and larvæ and natural selection has been a small percentage to act upon in the adult stage, and the specific characters of these beetles show little or no effect of natural selection.

SOME RECENT ADVANCES IN MOSQUITO WORK.

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Entomologist of the N. J. Agric. Experiment Stations.

CHARLES S. BECKWITH, B. Sc.,
Assistant Entomologist of the N. J. State Experiment Station.

At the outset the writers wish to state the present status of mosquito work in New Jersey. Approximately 95,000 acres of the salt marsh has been rendered reasonably free from mosquito breeding. This has involved the cutting of about 11½ million feet of ditches 10 inches wide and thirty inches deep or their equivalent, the building of 17.2 miles of dike, the installation of 76 sluices and tide gates (representing 842 sq. ft. of cross section outlet opening), the installation of one four and one twelve inch centrifugal pump and the connection of 100 acres of marsh with a large sewage pumping plant. Approximately 50 per cent of the reasonably permanent fresh water mosquito breeding pools scattered over 315,000 acres of upland has been permanently eliminated.

During the past year 3,289,120 linear feet of narrow 10 x 30 inch trenching or its equivalent has been installed in the salt marsh, 8,200 lineal feet of dike have been built, and 30 sluices and tide gates have been constructed and placed, affording 371 sq. ft. of cross section outlet. Approximately 95,000 acres of salt marsh have been patrolled throughout the mosquito season and the mosquito breeding thereon, which drainage systems did not prevent, destroyed in so far as possible. Approximately 315,000 acres of upland have been likewise patrolled, a large amount of draining and filling completed, and as nearly as possible all residual breeding destroyed. As a direct result a very considerable measure of protection has been given to 1¾ millions of people. The cost of the whole operation has been less than $210,000, or about 12 cents per capita.

Although a certain amount of drainage is yet to be done within the areas already covered, the great centers of population, which were formerly over run with mosquitoes, are now pretty well protected; and the present outlook is that the protection will grow better from year to year through the substitution of permanent for temporary elimination.

The great problem yet remaining is to free the sea shore and rural communities of southern New Jersey from the mosquito incubus by draining the remaining acreage of salt marsh.

Until 1912 the sole official agencies at work were the boards of health and the New Jersey State Agricultural Experiment Station, and for various reasons little was accomplished by the former. Since that year the County Mosquito Extermination Commissions and the New Jersey Experiment Station have worked on the problem in close co-operation.

In 1916, under the able and effective leadership of Dr. Haven Emerson, Commissioner of Public Health of the City of Greater New York, all salt marshes lying within its borders (except those on Staten Island, which were drained some years ago), have been drained or are now in the process of being drained. Under the authority of an act of 1916 a mosquito commission was organized in Nassau County, which lies in Long Island just east of the Brooklyn and Queens Division of Greater New York, and the work of draining the salt marshes, which had already been begun on the south side by private subscription, was undertaken in a systematic manner. The amount of work involved in Greater New York and Nassau County is shown by the fact that more than 5,000,000 lineal feet of narrow trenching or its equivalent have been cut or contracted for cutting. In addition to this, a certain amount of upland control work has been done, but with its exact nature and extent the writers are not familiar.

For the purpose of unifying the mosquito control work of the three states concerned, an Inter-State Anti-Mosquito Committee was formed under the leadership of Dr. Emerson. The committee consists of representatives of Connecticut, New York and New Jersey.

Having laid this basis the writers will now turn attention to some of the striking changes that have been made in response to the practical needs of mosquito control work.

CHANGES IN SALT MARSH DRAINAGE.

In 1904 at the close of the preliminary investigations of the problem it was thought to be necessary to drain only the marsh where breeding was found in such a way as to cause the water to flow in and out with the tide and to afford the killifish ingress at all times to all parts of the salt marsh known to breed. In

fact, this continued to be the thought until 1913, when it became clear to the senior author and others that there were at least two fundamental weaknesses in the working out of this plan. The first was the assumption that the salt marsh has certain breeding areas which may be determined in the course of one or two inspections and which if drained will free the marsh from breeding. The second was the assumption that all salt marshes respond to drainage systems of the above sort.

In 1913 the senior author was led to suspect and in 1914 to prove that certain areas in the salt marshes of the upper Hackensack Valley, which had been reported as in non-breeding territory, were really at times very prolific producers of salt marsh mosquitoes. This experience has since been repeated so frequently at different points of the supposedly drained salt marsh that the writers are convinced that every undrained area of grass, cattail or reed covered salt marsh is potentially dangerous unless it is swept with great frequency by the tide; and that even such tide swept areas may, in certain seasons be covered at such infrequent intervals as to permit breeding.

In 1914 the drainage systems established in Essex and Union Counties on the original plan utterly failed to prevent the issue of an enormous brood of salt marsh mosquitoes between July 15th and 20th. The failure was directly traceable to an unusual combination of long continued, extremely high tide with a period of much rain and cloudy weather. Other parts of the coast served with the same system of ditching, in many instances in a less completed state, were adequately protected. The difference seemed to lie in the fact that the east wind banked the waters up in land-locked Newark Bay and created a condition which did not obtain along the more open parts of the coast.

Although this failure was chargeable to an unusual condition of tide and weather, it was made possible by peculiar geographical location and might any year be repeated. It was, therefore, sufficient to condemn the system and to indicate that some radical change must be made.

After carefully considering the matter it was decided that the most feasible plan was to keep the sea off the marshes by dikes, to outlet the water through sluices and tide gates, and thus create a reservoir capable of absorbing heavy rainfall

without covering the surface and initiating mosquito breeding over large areas.

Accordingly, since 1913 new drainage has been planned to open not merely the places in which breeding has been found but all parts of the marsh, which are not swept at frequent intervals by the tide. Furthermore, since 1914 the areas on which the narrow trenching with its outlets failed to afford protection, have been placed under dike, sluice and tide gates as rapidly as possible.

Some salt marsh areas in the Hackensack Valley lie so low that their drainage by gravity flow is impracticable and they have in some instances become so charged with sewage as to breed the house mosquitoes as well as the salt marsh forms. In such places low head centrifugal pumps are being installed as rapidly as possible. A twelve inch pump of this type seems to be able to protect from 800 to 1,000 acres of land.

In the course of this diking, sluicing, and pumping work the problem of taking care of the sewage has presented itself. As a rule the open sewage streams have been arranged to open into tidal creeks, with a result that the ditches and creeks have soon become choked up and the raw sewage spread over large areas of the marsh. The plan adopted has been one of diking the borders of these sewage charged ditches and creeks, thereby causing the sewage to be carried out to sea by gravity, and to outlet the waters of the marsh either through sluices or by pumps into the sewage charged streams or other available outlets. Inasmuch as the city and borough engineers have usually planned to outlet their sewers into the best tidal streams of the areas in question it has been necessary as well as to deliver the marsh water through them.

ADVANCES IN KNOWLEDGE OF MOSQUITO DISTRIBUTION.

The method of determining the flight of salt marsh mosquitoes formerly practiced consisted in securing of reports from cooperating observers relative to the time when the mosquitoes arrive, and in efforts to follow their flights along trolley and railroad lines. With the advent of the automobile as a common means of transportation tracing the flight of salt marsh mosquitoes became a simple matter. In a day's time a freshly emerged brood could be traced to its source, and the basis promptly laid for the prevention of further

trouble from that area. This method of tracing broods of salt marsh mosquitoes was first tried in 1913 and the results were so satisfactory that it has been used constantly since that time.

In making a study of this sort, the usual plan is to drive to a point where the brood has been reported. From this point, collections are made outward along lines running to the north, west, south and east until no further specimens can be taken, or until the marsh from which the mosquitoes came has been reached. This will, without doubt reveal the direction of the source of the brood, unless the mosquitoes have been out long enough to lose their connection with the marsh from which they came. When the marsh from which the brood came, has been reached, some idea of the part from which it came can be had by running a collection line along the edges and discovering the point where the mosquitoes are most abundant. In most cases the place of breeding will be found nearest this point, but in others this process will offer little clue, for a heavy growth of trees may attract sufficient numbers to give a false impression or the direction of the wind may have produced concentration at a distant point. Nevertheless the determination of density gives a point of departure and is worth while when dealing with the problem of finding the pupal skins on a large area of salt marsh.

In running these collection lines the purpose is to determine the density of the mosquito fauna. It is, therefore, necessary to organize each collection on some sort of a unit basis, and in order to eliminate the serious interference of local conditions to make all collections in as nearly similar situations, especially as relates to cover, as possible. The whole series of collections is usually made within the limits of a single day. Starting in the morning about 8:00 A. M., collections along the first line are made. At each point the collector gets out of the machine, enters the type of growth selected and using two cyanide tubes catches as many specimens as possible in a limited period—say 15 minutes. He then reckons his catch in terms of so many specimens of the species concerned per minute. The distance between stations depends upon the area to be covered. When dealing with a small area the intervals are short, say, anywhere from ¼ to 1 mile, but when dealing with an issue that covers a large area the distances range from 2 to 5 miles.

In 1913 the success in tracing the salt marsh species lead to an attempt to trace the house mosquito which exhibited marked concentration in certain areas within which and in the vicinity of which no serious breeding of the species could be found. Daylight collections promptly proved inadequate because the house species would not readily attack the collector. Resort was then had to evening collections, but the variations in time required for one collector to cover the whole area seemed to introduce a variable fatal to the result. To meet this difficulty a number of collectors were employed along two lines of collection running through the mosquito zone at right angles to each other. Enough men were employed that the entire collection could be secured within the limits of 1½ hours. By this means the collections were found to bear an understandable relation to each other, and by following the directions of increasing density the source of breeding has been found. In this way a zone of house mosquitoes originating in a sewage charged salt marsh has been found which extended a distance of 2½ miles from the place of origin.

The fact that nearly all species were taken in these evening collections led the senior author to wonder whether the process might not be used to determine the density of the mosquito fauna throughout the protected area and thereby check up the efficiency of the control work and point out the places where greater effort was needed.

In 1914 he had an opportunity to try out the matter in Passaic County with the efficient assistance of Mr. David Young. He found that not only did the method seem to show up the efficiency of the control work, but served to demonstrate the inefficiencies in time to permit their correction before the householder was seriously troubled. The study seemed to show that there existed a mosquito fauna of such an attenuated character that the householder did not realize its existence and that variation in it could be determined in time to head off a really dangerous increase in number.

In 1915 the evening collection became a part of the regular mosquito control work in Essex, Passaic and Union Counties and in 1916 it was employed in Bergen, Essex, Passaic, and Union and utilized to some extent in Hudson, Middlesex, Monmouth, and Atlantic Counties. It has enabled these counties to detect promptly invasions from extra-territorial limits as well as incipi-

ent outbreaks within their boundaries. In 1916 it served to demonstrate that the dominant species in Bergen, Essex, Middlesex, Passaic and Union was the fresh-water swamp mosquito (*Aedes sylvestris* Theob.) and to show that the next problem consisted in the elimination of the breeding places of that species.

In 1914 Mr. Harold I. Eaton, Chief Inspector of the Atlantic County Commission, undertook the determination of the important factors governing the flight of the white marked salt marsh species (*A. sollicitans Wlk.*), for the purpose of determining where the limited amount of money available for the use of his commission could be spent with the prospect of affording the people of the county the largest measure of protection. Atlantic County has 50,000 acres of salt marsh and beyond its borders both to the north and the south lie many thousands of acres of undrained marsh. He found that this species took flight on winds of low velocity (10 miles an hour or less), high relative humidity, and high temperature. Under other conditions than these, migration proceeds with extreme slowness and covers only short distances. The studies of the writers before and after Mr. Eaton's tests simply serve to confirm and extend the results as stated.

In 1916, Dr. F. E. Chidester, working at the time under the senior author's direction, determined that, during the mosquito season, the principal factor in the time and geographical distribution of the brown salt marsh mosquito (*Aedes contator* Coq.) and the white marked salt marsh mosquito (*Aedes sollicitans* Wlk.) is the degree of salinity of the water to which they are subjected. He found sea water of salinity 6 to 8 per cent. to be favorable to the former and injurious to the latter, while a salinity of 10 to 15 per cent. was favorable to the latter and injurious to the former.

This discovery fitted well the observed distribution of the two species and seemed to offer an adequate explanation. Be that as it may, the brown salt marsh species is dominant in the spring and early summer throughout the area at a time when the water has been greatly diluted by melting snow and spring rains, and remains so throughout the season along the upper courses of the rivers where the salinity never rises much above the favorable per cent. The white marked salt marsh

species is dominant from early mid-summer on or during the period when the salinity rises to the degree favorable to it.

In the beginning of a study of this sort the student may be confused by his findings, for he may discover the larvæ of both species in the same pool with salinity either high or low. He will soon find, however, that larvæ under these conditions are all well grown or that the extremely small larvæ are of the species favored by the salinity. This mix-up of large larvæ of the two species is due when the salinity is extreme in either direction, in the writers opinion, to larval distribution by high tides.

SOME UNSOLVED PROBLEMS.

Many problems of mosquito work which are important from the standpoint of the practical work of control are yet without solution.

Ditching systems on the salt marsh are rapidly multiplying and some machinery especially adapted to the work of cleaning and repairing them should be devised.

Until the late summer of 1915 and the season of 1916 the fresh water swamp mosquito had formed, except in the vicinity of great swamps, a minor portion of the problem of control. The fact that since that time it has been the dominant form over a large part of the protected area indicates clearly that a further study of its life economy must be undertaken.

Collections of mosquitoes on the wings have failed to reveal the flight habits of *Anopheles quadrimaculatus Say*. It is rarely taken in collections except very near its place of breeding.

The oils used for larvicides need to be standardized and a really practicable larvicide soluble or at least miscible with water should be found.

A practicable way to reduce the mosquito fauna, which survives the faithful practice of the present methods, should be discovered, for the failure of the mosquito fighting machine in any particular way, during trying weather, all too promptly increases the ever present minimum to a troublesome number.

NEW SPECIES OF COLORADO SYRPHIDÆ.

CHARLES R. JONES.

Microdon similis n. sp.

Length 14 mm. Head black, clothed with yellowish pile, front wide, sides nearly parallel throughout, a narrow, shining oblique transverse groove running from the base of the antennæ to the eyes; antennæ dark fuscus, the first joint linear, equal or sub-equal in length to the second and third together, arista black, tip slightly reddish. Thorax of a bronze black, clothed with yellow pile. Scutellum rounded, black, with the apex slightly emarginate, but plain, pile of the same color as the thorax, slightly longer and more abundant. Abdomen black, short, slightly shining, less than twice as long as wide, finely punctulate; dorsum with stout black pile, the lateral margins with yellowish pilose, pile of the first segment long, whitish, and forms a distinct uninterrupted transverse cross-band on the posterior portion of the segment. Legs black, pile of the tibia whitish, hind metatarsi slightly diolated and not quite as long as the remaining joints together, clothed with short, stout, reddish pile. Wings sub-hyaline, the veins narrowly blackish.

Two specimens, Poudre Canon, Colorado., C. S. Mead, Coll.

M. similis differs from *M. tristis* in that the thorax of the latter is obsolete cupreous lineate and the former is not; that the antennæ of *tristis* is testaceous at the base while the antennæ of *similis* is entirely black; that the length of *tristis* is from 7 to 10 mm., while *similis* is 14 mm.; and in that the emarginated scutellum of *tristis* is armed with a sharp, tooth-like projection on each side and *similis* is only slightly emarginate and plain.

Melanostoma cherokeenensis n. sp.

Length, ♂, 7 mm., ♀, 7.5 mm. General color black, body linear, face bluish, yellow reflecting, white pollinose, pile black and white, tubercle rounded, not very prominent, shining black. Front of female slightly depressed, with whitish pollinose and black pile; vertex shining black, black pile, cheeks bluish black, white pollen and black pile near the eye, white pile along border. Occiput broad, whitish pollen and pile. Antennæ brownish black, third joint rounded. Thorax shining metallic green, with black and white pile. Pleura with white pollen and pile. Scutellum yellowish, lightly dusted with light pollen, which gives it a bluish reflection, dorsum with long black, sparse pile, bordered with whitish pile. Abdomen velvety, bluish-black with short, white pile and three interrupted yellow cross-bands, all separated from the lateral margin. In the female, the spots of the second segment are orange, quadrate, and near the middle of the segment; the lateral portion lightly dusted with white pollen; spots of the third and fourth segments

similar to the first, but nearer the anterior margin of the segment, and considerably larger; segments four and five with a narrow, yellow, posterior border. Legs black, with white pile, knees fuscous, hind metatarsi only slightly or not at all thickened, tarsi with short, stiff, yellow pile. Wings hyaline, stigma yellow. Male differs from female in having the face with more of a bluish tinge; the cheeks are black and the oral margin has a yellow spot on it. The scutellum is darker and the pile is about twice the length of that of the female; the first abdominal spots are triangular and very small, and the fifth segment has no yellow posterior margin.

Two males, one female. C. S. Mead, collector, Cherokee Park, 7600 ft., July 30, 1913.

Melanostoma johnsoni n. sp.

♀, 8 mm. Thorax blue or greenish metallic, head shining, bluish or green. Face prominent with whitish pile and lightly dusted on the sides with whitish pollen, tubercle and middle shining, a narrow transverse pollinose stripe below the antennæ which projects upward in the middle between the antennæ, front shining, lightly dusted on side with whitish pollen, a shining spot immediately above and surrounding the antennæ, pile black. Vertex shining, black pile. Antennæ elongate, third joint as long as the two preceding joints, sub-quadrate viewed from above, brownish, light-reddish underneath, arista brown, basal; occiput whitish pollinose, with whitish pile. Thorax metallic dark blue, or green, shining, with whitish pile. Scutellum of the same color as the thorax with marginal pile longer than the rest. Abdomen ovate, shining, brownish, with short white pile, which is longer on margin and near the base, and three pairs of yellowish abdominal spots. Second segment with two small oblique medial yellowish spots, segment three with two similar spots, but larger and more ovate. Spots on segment four similar in shape and size to the front pair. Legs testaceous, hind femora, except at the base and the tip, part of the tibiæ and the tarsus, fuscous, hind metatarsi slightly thickened. Wings hyaline, stigma yellow.

Habitat: Two females. S. A. Johnson, collector, Denver, Colorado, April 4, 1902.

Melanostoma monticola n. sp.

Length, ♀, 7 to 9 mm. Face projecting, slightly excavated below the antennæ, whitish pollinose, with white pile, shining black; epistoma projecting downward, tubercle prominent, a smaller one on oral margin; from tubercle up to the base of the antennæ a slight median depression; above the insertion of antennæ two slightly raised, black, arcuate ridges, meeting on the median line. Front shining metallic green, whitish pollinose on sides, black pilose, and slightly depressed; vertex shining metallic green, black pile; eyes converging at apex. Cheeks black, white pilose. Antennæ brownish, third joint reddish below, sub-ovate; arista bare. Thorax shining metallic green, white pile. Scutellum of the same color, pile short, a slight depression following

contour of scutellum making a narrow border on its entire posterior portion; pleuræ whitish pollinose, with white pile, abdomen shining black, narrowly ovate, pointed at tip; first segment sub-opaque, white pollinose, with white pile, second segment on the sides with a semi-quadrate yellow spot; third and fourth segments with larger yellow quadrate spots which touch the anterior margin of the segment, fifth segment with a pair of small triangular spots. The abdominal spots are lightly dusted with whitish pollen. Legs fuscous or brown, white pilose, hind metatarsi not thickened, hind femora black, or having base yellowish; coxæ black; wings hyaline; stigma yellowish.

Habitat: Six females, Cherokee Park, Estes Park and Carbondale, Colorado. C. S. Mead and J. C. Bradley, collectors. July 12, 1908; July, 1913.

Eupeodes braggii n. sp.

Length, 8 to 10 mm. Eyes bare; face whitish yellow with a black median line which extends from oral margin but does not reach the antennæ. Cheeks black. Front in male wholly yellow with black pile; front in female black, fading to light yellow towards the antennæ; occiput silvery pollinose, with whitish pile; a brownish crescentic spot above the antennæ. Thorax bluish or dark metallic green with pale yellowish pile; scutellum in both sexes translucent, greenish reflection; posterior margin distinctly yellow. Abdomen sub-opaque, with light colored pile; first segment and posterior portion of all segments shining. The second segment bears two oblong yellowish, attenuated, spots which are contiguous with lateral margins of abdomen. Segment three and four, each with a pair of slightly arcuate yellowish spots, which are separated from the lateral margin of the abdomen, inner angles rounded, outer anterior angles acute. Posterior portion of segments four and five narrowly margined with yellow. Legs yellow, or brown; femora black at base; wings hyaline.

Habitat: Seven specimens, 2 ♂, 5 ♀, Grand Junction, Fort Collins, Colorado. L. C. Bragg and G. P. Weldon, collectors, September 8, 1908.

Eupeodes weldoni n. sp.

Length, 10 mm. Eyes bare, face whitish, white pilose, with a black median line, extending from oral margin almost to the base of antennæ; cheeks black, upper front in female black, lower part yellow, with or without brown crescent-shaped spots above the roots of the antennæ. Vertex greenish, with light colored pile; occiput light with light pile. Antennæ varying from reddish brown to black. Thorax blackish metallic green, with pale yellowish pile; scutellum in female more or less translucent with yellowish pile and distinctly margined with yellow; abdomen black, sub-opaque; thinly pilose with whitish and black pile. The first segment and posterior portion of the second and third shining black; posteriorly, the fourth and fifth marginate with yellow; the fifth also yellow laterally, giving a complete yellow

border. Abdominal spots distinctly yellowish-white, those on the second segments transverse, and reaching the lateral margin. The spots on segments three and four arcuate, attenuated at their tips, and reach the lateral margin anteriorly, venter very pale yellow. Legs yellowish, with white pile, bases of femora black; wings hyaline.

Habitat: Three specimens (♀), Grand Junction, Fort Collins, Colorado. G. P. Weldon, Collector, August 14, 1909.

Syrphus flukei n. sp.

Length 8 mm. Face bluish yellow, only slightly pollinose, a bluish median stripe from roots of antennæ to oral margin. Oral margin brownish, shining; cheeks black, opaque, front dusky yellowish with yellow pile; frontal triangle slightly prominent, whitish pollinose, with black pile. Antennæ brownish red, a dash of wine red at roots of each, and light yellow lines running obliquely from them; third joint ovate, yellowish at base; arista brown, bare; eyes bare, contiguous; thorax shining metallic greenish yellow, with yellowish pile, dorsum with ramifying fern-like ferruginous markings, darker on margins, scutellum yellowish, clearer on margin, semi-translucent, covered with rather abundant long white pile.

Abdomen black, chiefly opaque, with three pairs of yellowish arcuate cross-bands, all reaching the margin; first segment wholly shining. Posterior margins of segments three, four and five, shining; first pair of abdominal spots semi-ovate with attenuated tips which reach the lateral margin only at extreme apex of the first third of segment, second and third pairs distinctly arcuate, with attenuated tips reaching lateral margin at junction of segments, inner angles extending forward and rounded, fourth segment with a narrow yellowish hind margin. Segment five entirely yellow. Legs brownish yellow; femora with rather long yellowish pile, base black, tarsus and metatarsus brownish. Wings hyaline, sub-costal cell brownish, stigma distinctly yellowish.

Habitat: One specimen, Fort Collins, Colorado, May 7, 1915. On plum blossom. Chas. Fluke, Collector.

Syrphus marginatus n. sp.

Length, male, 12 mm. Face yellow with a slight bluish tinge, shining, a brown median stripe from oral margin not reaching the antennæ; cheeks bluish black, shining, the oral margin anteriorly, connecting under the oral opening with the color on the opposite side; frontal triangle yellow, with black pile, greyish pollinose; a slender black or brownish arch above the base of the antennæ; vertical triangle small, metallic blue, with black pile; antennæ brown, along the underside more or less reddish, first two joints lighter than the third; third joint oval; eyes bare; thorax metallic green with moderately thick light pile; scutellum translucent yellowish, shining, with bluish opalescent reflection, chiefly light pile. Abdomen black, principally shining, with three pairs of yellow spots. The first pair transverse,

elongate oval with attenuated tips anteriorly which reach the lateral margins of the abdomen, inner angles rounded; the second and third pairs arcuate, a little oblique, convex behind, concave in front; outer margins acute and directed forward, the inner angles rounded. The fourth and fifth segments with a narrow yellow hind margin, the fifth with two yellow basal marginal spots; legs yellowish with base of femora black; hind femora with more black than the rest; hind tibiae and all tarsi brownish, lighter below. Wings hyaline, stigma brownish.

Habitat: Two males, Fort Collins, Colorado. L. C. Bragg, Collector. May 10, 1911.

NOTE:—*S. marginatus* differs from *S. arcuatus* in that the abdomen of the former is velvety black and sub-opaque, while the latter is principally or wholly shining, and that the abdominal spots are dull yellow and the first pair reach the lateral margin of *marginatus*, while the spots of the latter are bright yellow and are all separated from the margin.

Syrphus meadii n. sp.

Length, male and female, 10 to 12 mm. Face pale yellowish, with a shining black median stripe extending from oral margin but not reaching the antennæ; cheeks shining black, (from eye to oral margin); antennæ reddish brown, lighter on under side; frontal triangle yellow, pollinose, black pile; in the female with a medial black line resembling an inverted Y, slightly convex. Immediately above the antennæ are two large black spots; frontal triangle in the male yellow, silvery pollinose, and with black pile; vertical triangle black, black pile, eyes bare; occiput in the female rather broad, silvery pollinose, and with whitish pile; very narrow in the male.

Abdomen black, principally shining black and yellow pilose, three pairs of yellow cross-bands; the first abdominal cross-band distinctly interrupted and separated from the lateral margin, semi-oval, the inner angles rounded, the latro-anterior angles slightly acute. Second and third abdominal cross-bands coarctate in the middle; a brownish medial mark in the middle of these bands giving them the appearance of being subinterrupted. These bands are concavo-sinuate anteriorly and convexo-sinuate posteriorly. They do not reach the lateral margin and are cut off obliquely forming a sharp angle anteriorly and are rounded posteriorly. The fourth and fifth segments have a narrow yellowish posterior border; fifth segment with two small yellowish triangular spots at its base. The four anterior femora brownish with a black base, the black extending about one-third the length of femora; hind femora black with exception of apices which are brownish; tibiæ brownish, tarsi brown on underside, darker on top. Wings hyaline, subcostal cell brownish, darker at stigma.

Habitat: Eight specimens, seven females and one male. C. S. Mead, Fort Collins, Colorado, June 12, 1913.

Syrphus medius n. sp.

Length, 10 mm. Face yellowish, yellowish pilose, with a distinct blackish brown stripe in the middle, which begins at the oral margin, but does not reach the antennæ. Eyes bare. Antennæ brown, third joint lighter on the under side. Cheeks brownish black, separated from oral margin by a yellowish border completely cutting off the connection between the black on both sides (as in *S. americanus*). Front brownish yellow, with a slight greenish reflection, a darker median furcate line running from the vertex to the base of the antennæ, forming an inverted Y; lighter on sides, with black pile, a shining black spot above each antenna; vertex shining black, black pilose. Thorax bronze, shining, with fine yellowish pile; scutellum lighter, with the same colored pile; abdomen black, with three uninterrupted yellow cross-bands. The first abdominal cross-band entire; anterior margin distinctly concave; posterior margin gently sinuate, having a medial diameter of about one-half of that of the distal ends. The anterior margin extends directly to lateral margin of the body, while the posterior is cut obliquely a short distance from the tip and reaches the lateral margin in half its width. The bands of the second and third segments are equal in width throughout; both have a median anterior and posterior projection; attenuated at the ends and reach the lateral margins in the same manner as the first cross-band; fourth segment with a narrow yellow hind margin; fifth segment yellow, with a narrow transverse blackish spot in its middle; legs yellow, coxæ black, hind femora with a distinct brownish ring on the distal half, all tibiæ and tarsi yellow. Wings hyaline, stigma yellowish.

Habitat: Fort Collins, Colorado, one specimen. L. C. Bragg, Collector, August 22, 1911.

S. medius differs from *S. abbreviatus* in having the distinct brown stripe in the face; the brownish spots above the antennæ, the cross-band on the second segment entire, the cross-band of the third and fourth segments not all convex, sinuate, and the black color of the cheeks separated on the under side of the face by the yellow margin round the mouth.

S. medius differs from *S. americanus* chiefly in that the three principal yellow cross-bands attain the lateral margins of the abdomen.

Syrphus similis n. sp.

Length, 12.5 mm. Eyes globose bare, face yellowish, with bluish tinge, whitish pollinose and with sparse yellow pile; frontal triangle whitish pollinose, with two shining black spots above antennæ; the pile, and that of the vertex, black; vertex shining, metallic greenish; a brownish median stripe from vertex to black spot above antennæ; occiput broad, sides parallel, silvery pollinose, with rather abundant stubby, whitish pile; antennæ brownish, third joint oval, blackish at tip, with brown base; cheeks broad, yellowish. Thorax a dull, slightly shining black, with abundant light colored pile, and a bluish dorso-median

stripe; scutellum light yellow with chiefly black pile; pleura with a tuft of long yellow pile; halteres lemon yellow; abdomen black, opaque, principally black pile, first segment entirely shining, lateral margins of second, third and posterior portion of third and fourth shining. The three pairs of yellow stripes reach the lateral margins. The first pair, semi-ovate, attenuated laterally and rounded on inner angles; second and third pairs semi-rectangular, inner margins rounded, sides parallel, about two-thirds their length, thence slightly curved anteriorly and slightly attenuated, meeting the margins at the junction of preceding segment. Posterior margin of fourth and fifth segments bordered with a yellow transverse line; legs slender, yellowish, with chiefly black pile; bases of all femora black, all tibiæ yellow, inner margins of metatarsi of the front legs yellow, middle and hind metatarsi and tarsi brownish black; wings hyaline, yellowish at base, sub-costal cell brownish, darker at stigma.

Habitat: One specimen, female, Estes Park, 7600 ft., July 15, 1912, G. P. Weldon, Collector.

S. similis differs from *S. torvus* in that the eyes are globose and completely bare; and from *ribesii*, in that the femora are black at the base, while in the ♀ of *ribesii* they are yellow; and in that the abdominal bands are almost straight and attenuated, and that these spots show no convexity until they reach the point where the attenuation begins; from the rounded inner margins of the transverse bands up to the point of attenuation the abdominal spots are almost quadrate.

Sphaerophoria interrupta n. sp.

Length, ♀, 8 mm. Front black, shining, with a black median dash from the vertex, gradually becoming constricted in the middle to a little more than one-half its width, thence gradually broadening to its extreme width, and then tapering to a point above the antennæ; sides silvery pollinose, yellowish above the antennæ, with black and yellow pile; face pale yellow, with white pile and silvery pollen, except on the tubercle; oral margin narrowly brownish; cheeks yellow, with a dark brown spot; antennæ brownish, third joint rounded; arista slightly darker; occiput silvery pollinose, and with white pile; dorsum of thorax metallic greenish black, shining, with a distinct slightly interrupted spot at the base of the scutellum, the same shape and color of the scutellum, but slightly smaller; the anti-sutural stripe broad, yellowish, covered with whitish pollen, which gives it a bluish reflection; the post-sutural, slightly narrowed, entirely yellow, and terminating in an acute angle near the scutellum; pleuræ black, with silvery pollen and white pile; scutellum yellow, translucent, with sparse whitish pile; abdomen black, shining, with four yellow, interrupted cross-bands which reach the lateral margins; the first segment black; with inconspicuous yellowish side spots; second segment with two, semi-triangular, arcuate spots, which reach the lateral margins near the anterior portion of the segment,

inner angles acute; segments three, four and five each with a quadrate, interrupted transverse cross-band on the anterior portion, which reach the lateral margins in their full width, their inner angles slightly rounded; segments four and five narrowly margined, posteriorly, with yellow; legs brownish-yellow; four anterior femora with a brownish band near the middle; tibiæ and tarsi yellowish; hind tibiæ, tarsi, and femora, except at the bases and extreme apices, brownish; wings hyaline, stigma yellowish.

Habitat: One ♀, Happy Hollow, Colorado. C. S. Mead, Collector. August 13, 1913.

Brachyopa rufiabdominalis n. sp.

Length, 7 mm. Face light reddish brown, prominently produced forward, with light, silvery, glistening pollen and very fine white pubescence; slightly concave beneath the antennæ; frontal triangle shining, prominent, with or without a median suture. Cheeks a little darker red than the face and with a shining stripe from the eye to the oral margin; sparsely covered with long white pile. Antennæ situated on a semi-conical projection, of the same general color as the face but slightly darker; first joint about half as long as the second, of a slightly deeper red than the third, dorsally with a tuft of black hairs on each, third joint light red, about as long as first and second together, ovate; arista bare, dorso-basal. Vertex black, frontal portion with or without silvery pollen, eyes narrowly separated. Dorsum of thorax brown with black pile, covered with grayish pollen, anteriorly with two approximate dorso-medial blackish stripes, laterally, with a broad interrupted stripe; the transverse suture deep, shining; humeri with a reddish spot; pleuræ reddish brown; a reddish brown stripe extending from the scutellum to the base of the wing. Scutellum light reddish brown, beset with blackish and reddish pile, shining, with a very narrow median light stripe; abdomen slightly longer than the thorax, but little longer than wide, light reddish brown and entirely shining, with reddish pile; the posterior portion of segments one, two and three with a narrow, posterior, shining, brownish, transverse band, either entire or interrupted in the middle.

Legs of the same color as the abdomen, principally with light colored pile; on the under side of the hind femora and the apex of the four middle femora with stout black pile; tarsi darker brown; light at apex; the hind metatarsi slightly thickened at base and thence gradually tapering to apex; wings hyaline with a reddish tinge, anterior cross-vein before the middle of the discal cell and almost rectangular.

Habitat: Two male specimens. C. R. Jones, Collector. Rist Canon, Colorado, on wild plum. May 12, 1915.

B. rufiabdominalis differs from *B. cynops* in that the scutellum and abdomen are entirely shining, in that, in the former, the circular abdominal and the triangular spots of segments two and three are wanting, and it has the narrow posterior cross-band, and the lengths are different; in that the hind femora and

the apex of the anterior femora have stout black pile, and in that the posterior cross-vein is about two-thirds of the penultimate sections of the fourth vein, instead of being equal.

B. rufiabdominalis differs from *B. vacua* in the color of the thorax and its markings. *B. vacua* has three brown stripes and *B. rufiabdominalis* has four, two entire and two interrupted. *B. vacua* is 8–9 mm. and *B. rufiabdominalis* is 7 mm.

B. rufiabdominalis differs from *B. bicolor* Fallen, of Europe, in that the occiput of the latter is pale gray and with gray pile, the face is without pubescence, the eyes touch for about one-third of the distance from the ocelli to the antennæ; the scutellum has eight long black marginal hairs and is covered with short black pile, while in the former the occiput is black, whitish-pollinose and has black and white pile; the face has fine whitish pubescence on it; the eyes are distinctly separated, the nearest point of contingency is immediately below the ocelli; the scutellum has black pile dorsally, and the remainder is covered with reddish pile and lacks the eight black marginal bristles.

Volucella rufomaculata n. sp.

Length, ♀ 14 mm., ♂ 15 mm. Face yellowish chestnut, thickly clothed with a medium long, yellow pile; separated in both sexes by a narrow yellowish strip. Considerably excavated and bare below the antennæ. Cheeks shining black, black pilose, in the female with a small yellow triangular spot near the eye; in the male this spot connects with the narrow yellow stripe next to the eye. Antennæ reddish brown, lighter at tip, third joint elongate, widest at the base. Arista more than twice as long as the antenna, reddish, with long abundant feathery, black plume; front of the female distinctly yellow, rather narrow, converging at the apex with abundant long, yellow pile. Front of the male brown, shining, sparsely covered with whitish pile, frontal triangle of the male very small, yellow, with abundant long, yellow pile. Eyes of the female sparsely pilose throughout, in the male thickly pilose. Dorsum of thorax, bright shining blue with moderately long black pile. Anterior, lateral margins, posterior margin and pleura with abundant long, yellow pile. Scutellum light-yellow with abundant long, yellow pile. Abdomen shining black with yellow pile, more abundant on lateral margins of second and fourth segments. First segment black, shining, second segment with a pair of large, yellow lateral triangular spots connected on posterior margin with a reddish band, pile of the sides abundant, in the middle sparsely pilose. Third segment with a large red, dorso-medial spot, extending from the anterior margin about two-thirds of the length of the segment, narrowly interrupted in the female and slightly more interrupted in the male, with short erect reddish pile; laterally from this spot, in the female, with yellow pile,

in the male, black pilose, segment four with entirely yellow pile, in both a small black shining spot in the middle shows the ground color. Legs black, with stout black pile, tips of femora, bases of tibiæ and tarsi reddish brown. Wings with a brownish tinge, decidedly colored along the veins.

Habitat: One male; 1 female, C. R. Jones and C. S. Fluke, Collectors, Estes Park and Poudre Canon, August, 1915.

V. rufomaculata differs from *V. evecta* in the color of the thorax, the latter being black and the former being blue; the eyes of the female in *V. rufomaculata* are pilose throughout, and in *V. evecta* they are bare or at most pilose near the top; the abdomen, outside the second segment, in *V. evecta*, is entirely shining black, while in *V. rufomaculata* it has a large, red dorso-medial interrupted spot.

Mallota flavoterminata n. sp.

Length, ♂ 13 mm., ♀ 15.5 mm. Eyes bare, narrowly separated in the male; frontal triangle of the male thickly covered with grayish pollen, whitish pile along the sides and top. Front of the female narrowed above, greenish black, shining, with yellowish pile and a narrow stripe of grayish pollen on each side below the ocelli. Face, deeply concave below the antennæ to the tip of prominent tubercle; from tubercle to oral margin almost perpendicular; on the sides densely covered with grayish pollen. The broad, black median stripe is one-third the width of the face, wholly shining. Pile in the male, silvery, sparse, and rather long; in the female, short, whitish, mixed with golden yellow; the pollinose stripe in both sexes runs to the oral margin. Cheeks black, shining; antennæ brownish-black, the third joint covered with grayish pollen, a little wider than long; arista reddish, dorsal. Dorsum of thorax, in ground color, black with slight gray pollen on humeri, moderately shining, covered with long, thick golden pile. The female more densely covered than the male with a patch of whitish pile at the base of the wings. Scutellum, light yellowish, with the same colored pile as the thorax, but more dense and longer. Pleura with grayish pollen and long, light yellow pile. Abdomen, obtusely conical, shining, first segment with yellow and black pile, second and third with short, stout, black pile; the posterior margin of segments with a transverse band of yellowish pile; fourth segment shining, in the male, reddish brown with wholly yellow pile, more dense laterally; fifth segment reddish brown, sparsely pilose, fourth and fifth segments of the female black, shining, with yellow pile. Legs of both sexes black with black and white pile, the tarsi dark reddish, last joints and base of tarsal claws fuscus; hind femora in both sexes much thickened; hind tibiæ compressed arcuate. Wings hyaline with a distinct brown picture.

Two specimens, one male, C. S. Mead, Poudre Canon, Fort Collins, Colorado, 1913; one female, A. Maxson, on beet blossoms, Longmont, Colorado.

M. flavoterminata differs from *M. Sackeni* in that the marginal cell of the former is open and in the latter it is closed. The pile of the fourth and fifth segments in the former is the same color as the thorax, and not blackish as in *M. Sackeni*. *M. flavoterminata* differs from *M. cimbiciformis* in that the males are dichoptic, the pile and color of the abdomen and the brown spot in the wing.

Mallota palmeræ n. sp.

Length, ♂, 11-12 mm. Eyes bare, converging a short distance below the ocelli. Frontal triangle and vertex separated by a distinct transverse suture, frontal triangle with whitish pile, thickly covered with white pollen, a shining brown stripe above the antennæ. Face deeply concave from the base of the antennæ to the tip of the tubercle, slightly receding, thickly covered on the sides and below the antennæ with whitish pollen, leaving a black bare, median, shining stripe, about one-fifth the width of the face, pile whitish, and rather long on the sides; vertical triangle slightly darker than the frontal, and with moderately thick long white pile. Cheeks shining black. Antennæ brownish black, situated on a brownish truncated process; third joint lighter, rounded and covered with whitish pollen; arista reddish. Dorsum of thorax in ground color, black, moderately covered with whitish pollen which gives the appearance of two light colored abbreviated longitudinal lines. Pile abundant, short, and light yellow. Scutellum yellowish, shining, with fine yellowish and whitish pile. Abdomen long, narrow, obtusely conical, of a dark-brownish color, shining, and with light colored pile; first segment densely covered with white pollen and moderately long, whitish pile; second segment with a pair of brownish, rather indistinct, median transverse triangular spots which reach the lateral margins and are separated medially; the posterior portion narrowly margined with brown. The following segments similar to segment two, but the brownish portion less conspicuous. Legs blackish, with whitish pile, all tarsi apex of hind femora and hind tibiæ brownish, a tuft of stout brownish hair underneath the apex of hind tibiæ, hind femora considerably thickened in the male, arcuate, hind tibiæ arcuate. Wings hyaline, with a distinct brown spot from the base of the discal cell to beyond the anterior cross-vein.

Habitat: Two males, one, C. S. Mead, collected on buckwheat, Fort Collins, Colorado. C. R. Jones, Platteville, Colorado, taken on *Dichrophyllum marginatum*, June and August, 1915.

Xylota nigromaculata n. sp.

Length, ♀, 10 mm.; ♂, 8 mm. Head black, front considerable excavated below the antennæ, oral margin projecting; face blackish, light pollinose, pile whitish; cheeks black, shining, and white pile; front of female narrowed above, black, with two dashes of light pollen somewhat

remote from the eyes; front of the male black, with light pollen; antennæ short, fuscus, rounded; third joint scarcely longer than broad; arista bare, somewhat basal, reddish brown, lighter at tips; thorax metallic green, with short whitish pile, three dorso-medial cinerous stripes extending the entire length of thorax, the medial one about one-half the width of the others, meta-thoracic portion with additional cinereous stripes; scutellum the same color as thorax, with white pile, thicker and heavier on margin; abdomen bluish black, shining with whitish pile; second segment with triangular, metallic, greenish, shining side spots; legs nearly black, hind femora much thickened, hind tibiæ arcuate, reddish at apex, base of all tibiæ somewhat lutescent; front tarsi cinereous, inner margin of middle tibiæ with long whitish pile; wings blackish brown, stigma brown, anterior cross-vein oblique, wholly or partially surrounded by a black spot.

X. nigromaculata differs from *X. metallifera* to which it is closely related, in that the abdomen of the former is steel blue, shining, and has triangular metallic, greenish, shining side spots on the second segment; while the latter is opaque black; and in that the abdomen of the former does not have the elongated oval spots that occur in the latter. The former has distinctly thickened hind femora and the hind tibiæ are arcuate. These characters do not appear in the description of *X. metallifera*. I do not know of any specimens of the latter besides the types and these were unobtainable, so the description was all that was consulted.

Three specimens, two females and one male, Fort Collins, Colorado. The male was taken by S. A. Johnson at apple blossoms and the two females were reared from pupæ taken from an old decaying stump by E. C. Hotchkiss, April 21, 1903.

The following syrphid could not be exactly placed. In the key, it came nearest to *Xylota*, but the generic description did not fit, so, for lack of a better name, I have called it *Microxylota* and the species, *robii*.

Two specimens, Fort Collins, Colorado. C. S. Mead, Collector.

Microxylota n. g.

Small species, 6.5 to 7 mm., slender, metallic; head hemispherical, slightly broader than thorax; antennæ situated on slight conical projection, first two joints short, third more or less oval; arista dorsal, bare; face concave in profile, epistoma slightly projecting; eyes pubescent, contiguous in males; thorax rather large, metallic green; scutellum metallic green, thinned along border; abdomen slightly narrower than the thorax; metallic greenish black, shiny, flattened, sides nearly

parallel. Third segment slightly contracted (viewed dorsally); legs short, rather stout, hind femora short, decidedly thickened, moderately pilose with long golden hairs; hind tibiæ thickened, slightly arcuate, with a few stout spines at apex; metatarsi thickened. Marginal cell of wing open, third longitudinal vein gently curved, anterior cross-vein oblique, beyond middle of the discal cell. The fourth section of the fourth longitudinal vein zigzag with two stump veins projecting outward.

Type of genus *Microxylota Robii*.

Microxylota robii n. sp.

Length, 6.5 to 7 mm., face black with moderately thick, pale, yellowish pile, front narrow above, black, with silvery pollinose and sericeous pile; cheeks shining black; vertex shining black, black pile; eyes contiguous for a short distance, sparsely pilose; occiput shining black, extending broadly backwards; antennæ fuscus, pollinose, third joint rhomboid, somewhat pointed at tip; arista dorsal, bare, brownish. Dorsum of thorax shining, metallic greenish black, with two pollinose tapering stripes running from anterior portion to about middle of thorax, yellowish pilose; scutellum same color as thorax, thinned at the edge. Pile sparse, short, yellowish; abdomen approximately one-third longer than thorax; shining metallic greenish black, only four visible segments from above, sides nearly parallel, slightly tapering from anterior portion of second segment to the tip of abdomen; segments two, three and four with latro-medial, opaque, crescentic, whitish, pollinose depressions. Second segment broad, third slightly contracted; fourth rounding at tip, pile short, yellowish; legs strong, black, hind femora extremely thickened, shining black, with short, yellowish pile, tibiæ gradually dilated from base to apex, arcuate, base reddish brown, tarsi reddish brown; hind metatarsi incrassated at base, gradually tapering to apex. Wings sub-hyaline, stigma brown. The apical bounding vein of the first posterior cell zigzag with two stumps of a vein projecting forward.

Two specimens, males, collected by C. S. Mead, Fort Collins, Colorado, June and August, 1915.

NOTICE.

It is very important that I have a complete list of our members who are in the army and navy during the war. While we can hardly hope to reach them with the Annals, we may devise a way to keep in touch with them. As it will probably happen that many of them will not see this notice, I request their friends or former teachers to send me their names; it will be better for me to get a name two or three times than not at all.

J. M. ALDRICH,
Secretary-Treasurer.

West Lafayette, Ind., June 1, 1917.